FORM PTO-1390 (REV. 11-2000)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER **450118-02282**

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371	U.S. APPLICATION NO. (If known see 37 C.F.R. 1.5) **09/869897**

INTERNATIONAL APPLICATION NO. **PCT/JP00/00013**	INTERNATIONAL FILING DATE **5 JANUARY 2000**	PRIORITY DATE CLAIMED **7 JANUARY 1999**

TITLE OF INVENTION ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND INFORMATION RECORDING MEDIUM

APPLICANT(S) FOR DO/EO/US Atsushi INOMATA, Tamotsu IKEDA

Applicants herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).

4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).

5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))

    a. ☐ is attached hereto (required only if not communicated by the International Bureau).
    b. ☒ has been communicated by the International Bureau.
    c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))

    a. ☐ are attached hereto (required only if not communicated by the International Bureau).
    b. ☐ have been communicated by the International Bureau.
    c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
    d. ☒ have not been made and will not be made.

8. ☐ A English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ☒ A FIRST preliminary amendment.

14. ☐ A SECOND or SUBSEQUENT preliminary amendment.

15. ☐ A substitute specification.

16. ☐ A change of power of attorney and/or address letter.

17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 – 1.825.

18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).

19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

20. ☒ Other items or information:

    PCT/RO/101 PCT/ISA/210
    PCT/IB/301, 304, 308, 332
    30 Sheets of Drawings, 1 Page Abstract

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Date of Deposit: **July 6, 2001**

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Charles Jackson
(Typed or printed name of person mailing paper or fee)

Charles Jackson
(Signature of person mailing paper or fee)

00019039

U.S. APPLICATION NO (If known, see 37 CFR 1.50)	INTERNATIONAL APPLICATION NO. PCT/JP00/00013	ATTORNEY'S DOCKET NO. 450118-02282
09/869897		

21. ☒ The following fees are submitted	CALCULATIONS PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5):
Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37CFR 1.445(a)(2) paid to USPTO
and International Search Report not prepared by the EPO or JPO $1000.00

International preliminary examination fee (37 C.F.R. 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO $860.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but
international search fee (37 CFR 1.445(a)(2)) paid to USPTO $710.00

International preliminary examination fee paid to USPTO (37 CFR 1.482)
but all claims did not satisfy provisions of PCT Article 33(1)-(4......................................$690.00

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and all claims satisfied provisions of PCT Article 33(1)-(4)...$100.00

ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	$	
Total Claims	<u>22</u> - 20 =	<u>2</u>	x **$18.00**	$ 36.00	
Independent Claims	<u>9</u> - 3 =	<u>6</u>	x **$80.00**	$ 480.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)		+ **$270.00**		$	
TOTAL OF ABOVE CALCULATIONS =				$	
☐ Applicant claims small entity status. See 37 C.F.R. 1.27. The fees indicated above are reduced by ½. +				$	
SUBTOTAL =				$ 1,376.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$	
TOTAL NATIONAL FEE =				$ 1,376.00	
Fee for recording the enclosed assignments (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0.00	
TOTAL FEES ENCLOSED =				$ 1,376.00	
				Amount to be refunded:	$
				Charged:	$

a. ☒ One check in the amount of **$ 1,376.00** to cover the above fees are enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees.
   A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **50-0320**. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. WARNING: Information on this form may become public. **Credit card information should not be included on this form**. Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

WILLIAM S. FROMMER, ESQ.
FROMMER LAWRENCE & HAUG LLP
745 FIFTH AVENUE
NEW YORK, NEW YORK 10151

Dated: <u>July 6, 2001</u>

SIGNATURE

WILLIAM S. FROMMER
NAME

25,506
REGISTRATION NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Inomata, et al.

Filed.:   Filed Concurrently Herewith

Title of Invention: ERROR RATE ESTIMATING DEVICE, RECEIVER
                              USING ERROR RATE ESTIMATING DEVICE, ERROR
                              RATE ESTIMATING METHOD, RECEIVING METHOD
                              USING ERROR RATE ESTIMATING METHOD, AND
                              INFORMATION RECORDING MEDIUM

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PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Box Patent Application (35 U.S.C. 111)
Washington, D.C. 20231

Sir:

        Before the issuance of the first Office Action, please amend the above-identified

application as follows:

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00019019

IN THE TITLE

Please amend the title as follows:

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND INFORMATION RECORDING MEDIUM

IN THE SPECIFICATION

Please delete the paragraphs beginning at page 24, line 13 through page 30, line 22.

Please replace the paragraph beginning at page 1, line 10 with the following rewritten paragraph:

The present invention relates to an error rate estimating device and a receiver using the error rate estimating device, an error rate estimating method and a receiving method using the error rate estimating method, and an information recording medium, more particularly relates to an error rate estimating device and method for determining an error rate on a channel using the number of times of normalization performed by a circuit finding a state metric, a receiver using the error rate estimating device, an error rate estimating method and a receiving method using the error rate estimating method, and an information recording medium.

Please replace the paragraph beginning at page 17, line 12 with the following rewritten paragraph:

Still another object of the present invention is to provide an information recording medium provided with software for executing a method for realizing the above error rate estimating method and decoding method.

Please replace the paragraph beginning at page 17, line 16 with the following rewritten paragraph:

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According to a first aspect of the present invention, there is provided an error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

Please replace the paragraph beginning at page 18, line 12 with the following rewritten paragraph:

According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

Please replace the paragraph beginning at page 19, line 8 with the following rewritten paragraph:

According to a third aspect of the present invention, there is provided an information recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization,

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performed when generating a state metric, within a predetermined time and an estimation instruction for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmisssion system or each different coding rate based on the number of times of normalization counted when the count instruction is executed.

Please replace the paragraph beginning at page 19, line 20 with the following rewritten paragraph:

According to a fourth aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating device provided with a judging means for judging a transmission system or coding rate of the signal; a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

Please replace the paragraph beginning at page 20, line 17 with the following rewritten paragraph:

According to a fifth aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating method comprising (1)

a judging step of judging a transmission system or coding rate of the signal; (2) a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates; (3) an estimating step of estimating the error rate for each signal each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step; and (4) a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

Please replace the paragraph beginning at page 21, line 15 with the following rewritten paragraph:

According to a sixth aspect of the present invention, there is provided an information recording medium for providing information for control executed by a receiver receiving a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein the control information includes a judgement instruction for judging a transmission system or coding rate of the signal; a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time; an estimation instruction for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission shystem or each different coding rate based on the number of times of normalization counted in the count step; and a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

Please replace the paragraph beginning at page 23, line 18 with the following rewritten paragraph:

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According to a ninth aspect of the present invention, there is provided an information recording medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel, the control information including a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step; a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

IN THE CLAIMS:

Please delete claims 23-38 from the application.

Please amend claims 1, 5, 9, 10, 11 12, 13, 16, 19, 20, and 22 as follows:

1.   (Amended)   An error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal,

    the error rate estimating device provided with

    counting means for counting the number of times of normalization, performed when generating a state metric within a predetermined time and

    an estimating means for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively

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determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

5.   (Amended)   An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,

said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

9.   (Amended)   An information recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein said control information includes:

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and

an estimation instruction for estimating the error rate of the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted when said count instruction is executed.

10.   (Amended)   An information recording medium as set forth in claim 9, wherein the estimation instruction estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

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11.   (Amended)   An information recording medium as set forth in claim 9, wherein the estimation instruction inserts the number of times of normalization counted by the counting means into a predetermined function.

12.   (Amended)   An information recording medium as set forth in claim 9, wherein the count instruction counts only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate.

13.   (Amended)   An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device provided with:

a judging means for judging a transmission system or coding rate of the signal;

a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimating means for estimating the error rate for each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means; and

a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

16.   (Amended)   An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, said error rate estimating method comprising:

a judging step of judging a transmission system or coding rate of the signal;

a counting step of counting the number of times of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step; and

a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

19.   (Amended)   An information recording medium for providing information for control executed by a receiver receiving a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the signal;

a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in said count step; and

a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

20. (Amended) An error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:

a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimating means for estimating the error rate for each signal by the number of times of normalization counted by the counting means;

a multiplying means for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an outputting means for adding and outputting the error rate for each signal output from the multiplying means.

22. (Amended) An information recording medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel,

said control information including:

a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step;

a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step

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for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

REMARKS

The specification has been amended, claims 23-38 have been cancelled, and claims 1, 5, 9, 10, 11, 12, 13, 16, 19, 20, and 22 have been amended. All of these amendments reflect the amendments to the International Application made under PCT Article 34. The filing fee has been calculated based upon these new claims. The attached is captioned **"Version with markings to show changes made"** and indicate the changes that have been made herein.

Respectfully submitted,

FROMMER LAWRENCE & HAUG LLP
Attorneys for Applicant

By: _____
William S. Frommer
Reg. No. 25,506
Tel. (212) 588-0800

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the title:

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING

DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR

RATE ESTIMATING METHOD, AND INFORMATION [PROVIDING] RECORDING

MEDIUM

In the specification:

Paragraph beginning at page 1, line 10 has been amended as follows:

The present invention relates to an error rate estimating device and a receiver using the

error rate estimating device, an error rate estimating method and a receiving method using the

error rate estimating method, and an information [providing] recording medium, more

particularly relates to an error rate estimating device and method for determining an error rate on

a channel using the number of times of normalization performed by a circuit finding a state

metric, a receiver using the error rate estimating device, an error rate estimating method and a

receiving method using the error rate estimating method, and an information [providing]

recording medium.

Paragraph beginning at page 17, line 12 has been amended as follows:

Still another object of the present invention is to provide an information [providing]

recording medium provided with software for executing a method for realizing the above error

rate estimating method and decoding method.

Paragraph beginning at page 17, line 16 has been amended as follows:

According to a first aspect of the present invention, there is provided an error rate

estimating device for estimating the error rate of an quadrature-modulated signal when decoding

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the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

Paragraph beginning at page 18, line 12 has been amended as follows:

According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted in the counting step.

Paragraph beginning at page 19, line 8 has been amended as follows:

According to a third aspect of the present invention, there is provided an information [providing] recording medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an

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estimation instruction for estimating the error rate of [the signal by the number of times of normalization] <u>the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmisssion system or each different coding rate based on the number of times of normalization</u> counted when the count instruction is executed.

Paragraph beginning at page 19, line 20 has been amended as follows:

According to a fourth aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating device provided with a judging means for judging a transmission system or coding rate of the signal; a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal [by the number of times of normalization] <u>from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization</u> counted by the counting means; and a selecting means for selecting one of a plurality of error rates for each signal estimated by the estimating means.

Paragraph beginning at page 20, line 17 has been amended as follows:

According to a fifth aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating method comprising (1) a judging step of judging a transmission system or coding rate of the signal; (2) a counting step of counting the number of times of normalization, performed when a state metric is generated, for

each of the plurality of transmission systems or coding rates; (3) an estimating step of estimating

the error rate for each signal [by the number of times of normalization] each signal from the

corresondence between the number of times of normalization and the error rate respectively

determined for each different transmission system or each different coding rate based on the

number of times of normalization counted in the counting step; and (4) a selecting step of

selecting one of a plurality of error rates for each signal estimated in the estimating step.

Paragraph beginning at page 21, line 15 has been amended as follows:

According to a sixth aspect of the present invention, there is provided an information

[providing] recording medium for providing information for control executed by a receiver

receiving a signal modulated by a plurality of transmission systems or coding rates sent through a

channel, wherein the control information includes a judgement instruction for judging a

transmission system or coding rate of the signal; a count instruction for counting the number of

times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the signal [by the number of times of

normalization] from the correspondence between the number of times of normalization and the

error rate respectively determined for each different transmission shystem or each different

coding rate based on the number of times of normalization counted in the count step; and a

selection instruction for selecting one of a plurality of error rates for each signal estimated in the

estimating step.

Paragraph beginning at page 23, line 18 has been amended as follows:

According to a ninth aspect of the present invention, there is provided an information

[providing] recording medium for providing information for control executed by a receiver

receiving and decoding a signal modulated by a plurality of transmission systems or coding rates

sent through a channel, the control information including a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step; a multiplication instruction for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and an output instruction for adding and outputting the error rate for each signal output from the multiplying step.

In the claims:

1.   (Amended)   An error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal,

the error rate estimating device provided with

counting means [(91; 101, 102, 103)] for counting the number of times of normalization, performed when generating a state metric within a predetermined time and

an estimating means ']for estimating the error rate of [the signal by the number of times of normalization] the signal from the correspondence between the number of times of normalization and the error rate respectively determined for each different transmission system or each different coding rate based on the number of times of normalization counted by the counting means.

5.   (Amended)   An error rate estimating method for estimating an error rate of a signal when decoding an quadrature-modulated signal,

said error rate estimating method comprising:

a counting step of counting the number of times of normalization, performed

when generating a state metric, within a predetermined time and

an estimating step of estimating the error rate of [the signal by the number of

times of normalization] the signal from the correspondence between the number of times of

normalization and the error rate respectively determined for each different transmission system or

each different coding rate based on the number of times of normalization counted in the counting

step.

9. (Amended) An information [providing] recording medium for providing information

for control executed by a receiver receiving and decoding an quadrature-modulated signal

transmitted through a channel, wherein said control information includes:

a count instruction for counting the number of times of normalization, performed

when generating a state metric, within a predetermined time and

an estimation instruction for estimating the error rate of [the signal by the number

of times of normalization] the signal from the correspondence between the number of times of

normalization and the error rate respectively determined for each different transmission system or

each different coding rate based on the number of times of normalization counted when said

count instruction is executed.

10. (Amended) An information [providing] recording medium as set forth in claim 9,

wherein the estimation instruction estimates the error rate based on a table establishing

correspondence between the number of times of normalization and the error rate on a channel.

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11.   (Amended)   An information [providing] recording medium as set forth in claim 9,

wherein the estimation instruction inserts the number of times of normalization counted by the

counting means into a predetermined function.

12.   (Amended)   An information [providing] recording medium as set forth in claim 9,

wherein the count instruction counts only the number of times of normalization for a signal of a

predetermined transmission system or a predetermined coding rate.

13.   (Amended)   An error rate estimating device for estimating an error rate of a signal

when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device provided with:

a judging means [(62)] for judging a transmission system or coding rate of the

signal;

a counting means [(91)] for counting the number of times of normalization,

performed when generating a state metric, for each of the plurality of transmission systems or

coding rates;

an estimating means [(92, 111)] for estimating the error rate for each signal [by

the number of times of normalization] from the correspondence between the number of times of

normalization and the error rate respectively determined for each different transmission system or

each different coding rate based on the number of times of normalization counted by the counting

means; and

a selecting means [(32, 33)] for selecting one of a plurality of error rates for each

signal estimated by the estimating means.

16.   (Amended)   An error rate estimating method for estimating an error rate of a signal

when decoding a signal modulated by a plurality of transmission systems or coding rates, said

error rate estimating method comprising:

a judging step of judging a transmission system or coding rate of the signal;

a counting step of counting the number of times of normalization, performed

when a state metric is generated, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal [by the number of

times of normalization] from the correspondence between the number of times of normalization

and the error rate respectively determined for each different transmission system or each different

coding rate based on the number of times of normalization counted in the counting step; and

a selecting step of selecting one of a plurality of error rates for each signal

estimated in the estimating step.

19.   (Amended)   An information [providing] recording medium for providing information

for control executed by a receiver receiving a signal modulated by a plurality of transmission

systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the

signal;

a count instruction for counting the number of times of normalization, performed

when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the signal [by the number

of times of normalization] from the correspondence between the number of times of

normalization and the error rate respectively determined for each different transmission system or

each different coding rate based on the number of times of normalization counted in said count

step; and

a selection instruction for selecting one of a plurality of error rates for each signal

estimated in the estimating step.

20.   (Amended)   An error rate estimating device for estimating an error rate of a signal

when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:

a counting means [(91)] for counting the number of times of normalization,

performed when generating a state metric, for each of the plurality of transmission systems or

coding rates;

an estimating means [(92)] for estimating the error rate for each signal by the

number of times of normalization counted by the counting means;

a multiplying means [(111)] for determining a value for multiplication with the

error rate for each signal according to a value of the error rate estimated by the estimating means

for a predetermined transmission system or coding rate among the transmission systems or

coding rates and multiplying with that value; and

an outputting means [(32, 33)] for adding and outputting the error rate for each

signal output from the multiplying means.

22.   (Amended)   An information [providing] recording medium for providing information

for control executed by a receiver receiving and decoding a signal modulated by a plurality of

transmission systems or coding rates sent through a channel,

said control information including:

a count instruction for counting the number of times of normalization, performed

when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimation instruction for estimating the error rate for each signal by the

number of times of normalization counted in the counting step;

a multiplication instruction for determining a value for multiplication with the

error rate for each signal according to a value of the error rate estimated by the estimating step for

a predetermined transmission system or coding rate among the transmission systems or coding

rates and multiplying with that value; and

an output instruction for adding and outputting the error rate for each signal

output from the multiplying step.

DESCRIPTION

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE

5   ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD,

RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND

INFORMATION PROVIDING MEDIUM

TECHNICAL FIELD

10   The present invention relates to an error rate

estimating device and a receiver using the error rate

estimating device, an error rate estimating method and a

receiving method using the error rate estimating method,

and an information providing medium, more particularly

15   relates to an error rate estimating device and method for

determining an error rate on a channel using the number

of times of normalization performed by a circuit finding

a state metric, a receiver using the error rate

estimating device, an error rate estimating method and a

20   receiving method using the error rate estimating method,

and an information providing medium.

BACKGROUND ART

At the present, in Japan, provision of a digital

broadcasting service using a successor to the BS4

25   scheduled to be launched as a broadcasting satellite is

being discussed at the Radio Regulatory Council. In this
digital broadcasting service, 8 SPK (Phase Shift Keying),
QPSK (Quadrature PSK), and BPSK (Binary PSK) are defined
as channel coding systems.

5   Figure 1 is a block diagram of an example of the
configuration of a transmitter and a receiver. The
transmitter 1 is comprised of a video, audio, or other
information source 2, a coder 3, a puncturing unit 4, and
a mapping unit 5. The information source 2 outputs data

10   to be coded and transmitted to the coder 3. The coder 3
performs trellis coding on input 1-bit data by the coding
rate R=1/2 and outputs it to the puncturing unit 4 as a
2-bit coded word. The puncturing unit 4 punctures the
input 2-bit data and outputs it to the mapping unit 5.

15   The mapping unit 5 assigns the input 2-bit coded word to
one signal point among four signal points shown in Fig. 5
by an quadrature modulation system and outputs an I-
signal and Q-signal of the signal point to a channel 6.

       A receiver 7 is comprised of a bit insertion unit 8,

20   a decoder 9, and decoded information 10. The bit
insertion unit 8 inserts bits into the received signals
(I, Q) input via the channel 6 and outputs them to the
decoder 9. The decoder 9 performs trellis decoding on the
input signal and outputs it as decoded information 10.

25   The decoded information 10 shows decoded data. An image

and sound can be obtained by reproducing the decoded

information 10 with a not shown reproducing apparatus.

Information of the state metric output from the

decoder 9 is supplied to a monitoring circuit 11. The

5 monitoring circuit 11 determines an error rate on the

channel 6 and outputs the information as error rate

information 12. The error rate information 12, for

instance, is used as data when adjusting the orientation

of the antenna for receiving the data in a direction

10 giving the lowest error rate.

Figure 2 is a block diagram showing the

configuration of a coder 3. The coder 3 is a

convolutional coder. An input 1-bit data b_0 is coded to

2-bit data (c_1, c_0) and output. The output 2-bit data c_1,

15 c_0 is generated by calculating the data b_0 by a processor

comprising delay circuits 21 and 22 and exclusive OR

circuits 23 and 24.

That is, the data b_0 is input to the delay circuit

21, the exclusive OR circuit 23, and the exclusive OR

20 circuit 24. The data b_0 input to the delay circuit 21 is

delayed by one unit time and output to the delay circuit

22 and the exclusive OR circuit 23. The data input to the

delay circuit 22 is further delayed for one unit time and

output to the exclusive OR circuits 23 and 24. The

25 exclusive OR circuit 23 calculates the exclusive OR of

the three bits of data, that is, the data b_0 currently input in the coder 3, the data input to the coder 3 one time unit before, and further the data input to the coder 3 two time units before, to generate the output data c_1.

5   The exclusive OR circuit 24 calculates the exclusive OR of the data b_0 currently input in the coder 3 and the data input to the coder 3 two time unit before to generate an output data c_0.

The output data (c_1, c_0) output from the coder 3 are

10   input to the puncturing unit 4 in this way. The puncturing unit 4 outputs the input data to the mapping unit 5 as is when outputting the data of the coding rate $R=1/2$ to the channel 6 and punctures the input data and outputs it to the mapping unit 5 when outputting data of

15   the coding rate $R=3/4$ to the channel 6.

Figures 3A and 3B are views for explaining the puncturing. As shown in Fig. 3A, the puncturing unit 4 punctures the input data (c_1, c_0) in accordance with the puncturing table shown in Fig. 3B and outputs the data

20   (p_1, p_0).

In the puncturing table shown in Fig. 3B, "1" shows the input data output as the data p_0 or data p_1 and "0" shows the input data not output (erased). For instance, the data shown in Fig. 4B is output when the data shown

25   in Fig. 4A is input.

That is, as shown in Fig. 4A, when data X_1 to X_6 are input as the input data c_1 and the data Y_1 to Y_6 are input as the input data c_0 to the puncturing unit 4, since these are input in the order of the data c_0, c_1, when the data are sequentially input in the order of Y_1, X_1, Y_2, X_2, ..., Y_6, X_6 to the puncturing unit 4, as shown in Fig. 4B, the data X_1, Y_3, X_4, and Y_6 are output as the output data p_1 and the data Y_1, X_2, Y_4, and X_5 are output as the output data p_0. Note that since the output data is output in the order of the data p_0, p_1, the data is output from the puncturing unit 4 in the order of Y_1, X_1, X_2, Y_3, Y_4, X_4, X_5, and Y_6.

The input data Y_1, X_1 are output as output data p_0, p_1 as is since they correspond to positions of the value 1 of the puncturing table, but the input data Y_2 is deleted since it corresponds to a position of a value 0 of the puncturing table. The next output data X_2 (corresponding to a position of a value 1 of the puncturing table) is output as the data p_0. Below, in the same way, data corresponding to a position of a value 0 of the puncturing table are deleted and data corresponding to a position of a value 1 of the puncturing table are output.

The data output from the puncturing unit 4 in this way are mapped onto the signal points in the quadrature

coordinate system based on the I-axis and Q-axis as shown in Fig. 5 by the mapping unit 5. The signal points are arranged at equal intervals 90 degrees apart. "p_1" shown in Figs. 3A and 3B is the MSB (most significant bit) in the signal point assignment, while "p_0" is the LSB (least significant bit) in the signal point assignment. That is, a signal point assignment may be expressed as (p_1, p_0).

The data mapped by the mapping unit 5 is input to the bit insertion unit 8 of the receiver 7 through the channel 6. Figures 6A and 6B are views explaining bit insertion. Bit insertion is processing opposite to the puncturing performed in the puncturing unit 4, that is, processing for outputting received data as is to the decoder 9 when receiving data of the coding rate R=1/2 and inserting deleted data (bits) when receiving data of the coding rate R=3/4.

As shown in Fig. 6A, the bit insertion unit 8 inserts bits in the data (p'_1, p'_0) from the transmitter 1 through the channel 6 in accordance with the depuncturing table shown in Fig. 6B and outputs the output data (c'_1, c'_0). A value 1 of the depuncturing table shown in Fig. 6B indicates to output the input data as is, while the value 0 indicates to insert 0 (insert a bit).

When for example input data shown in Fig. 7A (data

output from the puncturing unit 4 and shown in Fig. 4B) is input to the bit insertion unit 8, the data shown in Fig. 7B is output. The data transmitted from the transmitter 1 is in the order of the data p_0, p_1, so the

5   order of input into the bit insertion unit 8 of the receiver 7 also becomes the data p'_0, p'_1. Further, the order of the data output from the bit inserted unit 8 becomes the data c'_0, c'_1.

Note that the data p'_0, p'_1 show the data p_0, p_1

10   output from the transmitter having the possibility of generation of error due to the effect of noise or distortion in the channel 6.

Therefore, the data X_2 input as the input data p'_0 is data corresponding to a position of a value 0 of the

15   depuncturing table, so is output as the data c'_0 in a form with 0 inserted instead of the input data X_2. The data X_2 is output as the data c'_1. In this way, input data positioned at a value 0 is output with 0 inserted.

Data with a bit inserted by the bit insertion unit 8

20   in this way is output to the decoder 9.

Figure 8 is a block diagram of the inner configuration of the decoder 9. The decoder 9 is comprised of a branch metric generator 31 (hereinafter referred to as a "BM generator 31"), an add, compare, and

25   select (ACS) circuit 32, and a path memory 33. The signal

input to the decoder 9 is first input to the BM generator
31 calculating the square of the Euclidean distance from
a received signal point with the noise and distortion of
the channel to a signal point to originally be received

5   and generating the same as a branch metric. The branch
metrics generated at the BM generator 31 are cumulatively
added and compared in accordance with a convolutional
coding trellis by the ACS circuit 32 to calculate the
state metric of each state.

10   Figure 9 is a trellis transition diagram for
explaining the calculation of a state metric performed by
the ACS circuit 32. As the paths in the state 00 at the
time t+1, two paths may be considered: the path of the
case where the branch metric BM00 is selected at the

15   state 00 at the time t and the path of the case where the
branch metric BM11 is selected at a state 01 at the time
t. The value obtained by adding the value of the branch
metric BM00 to the state metric of the state 00 at the
time t and the value obtained by adding the value of the

20   branch metric BM11 to the state metric of the state 01 at
the time t are compared and the path with the smaller
value is used as the state metric of the state 00 at the
time t+1.

Similarly, the state metrics of the states 01, 10,

25   and 11 at the time t+1 are calculated.

The ACS circuit 32, as described above, controls the path memory 33 while inferring the state transition at the coding side (transmission side). If there is no noise or distortion on the channel, the input signal matches with the original transmission signal point, so the BM generator 31 generates 0 for the branch metric relating to the transmission signal point and the square of the distance between the signal points for other branch metrics. Therefore, when these branch metrics are cumulatively added in accordance with the state transition diagram and the state metric calculated in the ACS circuit 32, the state metric remains 0 for the original path, but the state metric is a large value for other paths, so the transmission signal sequence can be inferred from this.

Here, consider the case where the input signal includes noise. Since the input signal is comprised of the original transmission signal point plus noise, the branch metric relating to the original transmission signal point does not always become 0 and has indefiniteness depending on the noise power. In the same way, for other branch metrics as well, the square of the distance between signal points also has indefiniteness depending on the noise power.

However, when the noise power is small, the ACS

circuit 32 cumulatively adds the branch metrics in
accordance with the state transition diagram and
calculates the state metric. Since the state metric is a
small value for the original path, but the state metric

5 has a large value for other passes, it is possible to
estimate the transmission signal sequence.

Figure 10 is a block diagram of the configuration of
the ACS circuit 32. The ACS circuit 32 is comprised of
the state 00 generating unit 41, state 01 generating unit

10 42, state 10 generating unit 43, and state 11 generating
unit 44 for finding the state metrics for the states 00,
01, 10, and 11. The state 00 generating unit 41 is
comprised of adders 45-1 and 46-1 and a selector 47-1.
The state metric of the state 00 and branch metric BM00

15 at the time t are input to the adder 45-1 and added. In
the same way, the state metric of the state 01 and branch
metric BM11 at the time t are input to the adder 46-1 and
added.

The selector 47-1 compares the values input from the

20 adder 45-1 and the adder 46-1 and outputs the smaller
value to a register 48-1. The register 48-1 stores the
value of the state metric of the state 00 at the time
t+1, output from the selector 47-1, as a value at the
time when finding the state metric of the state 00 at the

25 next time t+2, and outputs it to the path memory 33.

The state 01 generating unit 42 is comprised of the adders 45-2 and 46-2 and the selector 47-2. The state metric of the state 10 and branch metric BM10 at the time t are input to the adder 45-2 and added. The state metric of the state 11 and the branch metric BM01 at the time t are input to the adder 46-2 and added. The selector 47-2 compares the values input from the adder 45-2 and the adder 46-2 and outputs the smaller value to a register 48-2. The register 48-2 stores the value of the state metric of the state 01 at the time t+1, output from the selector 47-2, as a value at the time when finding the state metric of the state 01 at the next time t+2, and outputs it to the path memory 33.

The state 10 generating unit 43 is comprised of the adders 45-3 and 46-3 and the selector 47-3. The state metric of the state 00 and the branch metric BM11 at the time t are input to the adder 45-3 and added. The state metric of the state 01 and the branch metric BM00 at the time t are input to the adder 46-3 and added. The selector 47-3 compares the values input from the adder 45-1 and the adder 46-3 and outputs the smaller value to a register 48-3. The register 48-3 stores the value of the state metric of the state 10 at the time t+1, output from the selector 47-3, as a value at the time when finding the state metric of the state 10 at the next time

t+2, and outputs it to the path memory 33.

The state 11 generating unit 44 is comprised of the adders 45-3 and 46-3 and the selector 47-4. The state metric of the state 10 and the branch metric BM01 at the

5   time t are input to the adder 45-4 and added, while the state metric of the state 11 and branch metric BM10 at the time t are input to the adder 46-4 and added. The selector 47-4 compares the values input from the adder 45-1 and the adder 46-4 and outputs the smaller value to

10   a register 48-4. The register 48-4 stores a value of the state metric of the state 11 at the time t+1, output from the selector 47-4, as the value at the time when finding the state metric of the state 11 at the next time t+2, and outputs it to the path memory 33.

15   However, the bit length in the above ACS circuit 32 is limited, so overflow occurs due to the addition of the branch metrics, therefore processing is necessary to prevent overflow from occurring. The processing to prevent overflow from occurring in this way is called

20   "normalization". Figure 11 shows the configuration of the ACS circuit 32 for calculating a state metric while performing normalization.

In the configuration of the ACS circuit 32 shown in Fig. 11, the value output from the state 00 generating

25   unit 41 is supplied to the register 48-1 through the

subtracter 51-1, the value output from the state 01 generating unit 42 is supplied to the register 48-2 through the subtracter 51-2, the value output from the state 10 generating unit 43 is supplied to the register

5 48-3 through the subtracter 51-3, and the value output from the state 11 generating unit 44 is supplied to the register 48-4 through the subtracter 51-4. The values output from the registers 48-1 to 48-4 are input to the path memory 33 and the minimum value processor 52.

10 The minimum value processor 52 calculates the minimum value of the state metrics output from the registers 48-1 to 48-4 and outputs the value to the subtracters 51-1 to 51-4, the path memory 33, and the monitoring circuit 11. The subtracters 51-1 to 51-4

15 subtract the value input from the minimum value processor 52 from the values input from the state generating units 41 to 44 respectively corresponding to the subtracters 51-1 to 51-4. In this way, normalization is carried out.

Figure 12 is a block diagram of the configuration of

20 the monitoring circuit 11. The monitoring circuit 11 is comprised of an accumulator 61 and a table 62. The accumulator 61 cumulatively adds the values of the minimum state metric for a predetermined time and outputs the cumulative total to the table 62. The table 62 is

25 comprised of a ROM (read only memory) and the like and

determines the noise of the channel by using a table
establishing correspondence between a value output from
the accumulator 61 and noise.

Figure 13 is a block diagram of the configuration of

5 the accumulator 61. A timer 71 generates a pulse at a
predetermined cycle and supplies the pulse to a minimum
SM (status metric) value accumulator 72. The minimum SM
value accumulator 72 receives as input the minimum value
of the state metric output from the minimum value

10 processor 52 (Fig. 11) and the value output and fed back
from the minimum SM value accumulator 72. The value
output from the minimum SM value accumulator 72 and the
pulse generated at the timer 71 are supplied to the
register 73.

15 The operation of the accumulator 61 shown in Fig. 13
will be explained referring to the timing chart in Figs.
14A to 14D. The pulse generated by the timer 71 (Fig.
14A) is a reset pulse for resetting the cumulative total
of the minimum SM values. The minimum SM value

20 accumulator 72 cumulatively adds the minimum SM values
input between the pulse generated at a predetermined time
t and the pulse generated at the next time t+1 and
outputs the value to the register 73.

When the minimum SM value accumulator 72 receives as

25 input a value such as shown in Fig. 14B as the minimum SM

value, a cumulative value shown in Fig. 14C is output.
That is, when receiving as input a pulse from the timer
71 at the time t, the minimum SM value accumulator 72
resets the cumulative total to 0. It then successively

5   cumulatively adds the minimum SM values input between t
and t+1. Further, when a pulse from the timer 71 is input
again at the time t+1, the cumulative total is reset to
0.

The register 73 stores the value input from the

10   minimum SM value accumulator 72 at the time when the
pulse is input from the timer 71 and outputs the value to
the table 62.

Figures 15A and 15B are views of an example of a
table stored in the table 62. When the transmission

15   system is QPSK and the coding rate R is ½, the magnitude
of the transmission error rate (C/N) of data on the
channel is judged in accordance with the table shown in
Fig. 15A. When the transmission system is QPSK and the
coding rate R is 3/4, the magnitude of the transmission

20   error rate of the data on the channel is judged in
accordance with the table shown in Fig. 15B.

Judging the error rate on the channel as described
above required the minimum value processor 52 for
calculating the value of the minimum state metric, the

25   minimum SM value accumulator 72 provided at the

monitoring circuit 11 and cumulatively adding the output

from the minimum value processor 52, and the register 73

for storing the cumulative total. There was the problem

that these circuits (apparatuses) 52, 72, and 73 became

5   larger in circuit size along with an increase in the

number of transmission signal points (number of states)

transmitted from the transmitter 1 (four states in the

above example).

Further, there was the problem that the calculation

10   time also increased along with an increase in the number

of states. Furthermore, in the BS transmission system, it

is being proposed to transmit using different

transmission systems for time division. When a plurality

of transmission systems are used, there was the problem

15   that, with the monitoring circuit 11 shown in Fig. 12, it

became difficult to judge the transmission error rate.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide an

20   error rate estimating device used for a receiver which

enables a shortening of the calculation time and a

reduction of the circuit scale by judging the error rate

on a channel using the number of times of normalization

performed in a circuit for finding a state metric.

25   Another object of the present invention is to

provide a receiver using the above error rate estimating device.

Still another object of the present invention is to provide an error rate estimating method enabling a shortening of the calculation time when judging the error rate on the channel using the number of times of normalization performed in a circuit for finding a state metric.

Still another object of the present invention is to provide a decoding method using the above possible error rate estimating method.

Still another object of the present invention is to provide an information providing medium provided with software for executing a method for realizing the above error rate estimating method and decoding method.

According to a first aspect of the present invention, there is provided an error rate estimating device for estimating the error rate of an quadrature-modulated signal when decoding the signal, the error rate estimating device provided with a counting means for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimating means for estimating the error rate of the signal by the number of times of normalization counted by the counting means.

Preferably, the estimating means estimates the error rate based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

5   Alternatively, preferably the estimating means inserts the number of times of normalization counted by the counting means into a predetermined function.

Alternatively, the counting means counts only the number of times of normalization for a signal of a

10   predetermined transmission system or a predetermined coding rate.

According to a second aspect of the present invention, there is provided an error rate estimating method for estimating an error rate of a signal when

15   decoding an quadrature-modulated signal, the error rate estimating method comprising (1) a counting step of counting the number of times of normalization, performed when generating a state metric, within a predetermined time and (2) an estimating step (3) of estimating the

20   error rate of the signal by the number of times of normalization counted in the counting step.

Preferably, in the estimating step, the error rate is estimated based on a table establishing correspondence between the number of times of normalization and the

25   error rate on a channel.

Alternatively, preferably, in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

Alternatively, in the counting step, only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

According to a third aspect of the present invention, there is provided an information providing medium for providing information for control executed by a receiver receiving and decoding an quadrature-modulated signal transmitted through a channel, wherein the control information includes a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time and an estimation instruction for estimating the error rate of the signal by the number of times of normalization counted when the count instruction is executed.

According to a fourth aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate estimating device provided with a judging means for

judging a transmission system or coding rate of the

signal; a counting means for counting the number of times

of normalization, performed when generating a state

metric, for each of the plurality of transmission systems

5   or coding rates; an estimating means for estimating the

error rate for each signal by the number of times of

normalization counted by the counting means; and a

selecting means for selecting one of a plurality of error

rates for each signal estimated by the estimating means.

10   Preferably, the selecting means selects the error

rate according to the transmission system or the coding

rate judged by the judging means.

Alternatively, preferably the selecting means

selects an error rate to be output by comparing a

15 plurality of error rates input with a predetermined

reference value.

According to a fifth aspect of the present

invention, there is provided an error rate estimating

method for estimating an error rate of a signal when

20 decoding a signal modulated by a plurality of

transmission systems or coding rates, the error rate

estimating method comprising (1) a judging step of

judging a transmission system or coding rate of the

signal; (2) a counting step of counting the number of

25 times of normalization, performed when a state metric is

generated, for each of the plurality of transmission

systems or coding rates; (3) an estimating step of

estimating the error rate for each signal by the number

of times of normalization counted in the counting step;

5   and (4) a selecting step of selecting one of a plurality

of error rates for each signal estimated in the

estimating step.

Preferably, in the selecting step, the error rate is

selected according to the transmission system or the

10   coding rate judged by the judging step.

Alternatively, preferably, in the selecting step, an

error rate to be output is selected by comparing a

plurality of error rates input with a predetermined

reference value.

15   According to a sixth aspect of the present

invention, there is provided an information providing

medium for providing information for control executed by

a receiver receiving a signal modulated by a plurality of

transmission systems or coding rates sent through a

20   channel, wherein the control information includes a

judgement instruction for judging a transmission system

or coding rate of the signal; a count instruction for

counting the number of times of normalization, performed

when generating a state metric, within a predetermined

25   time; an estimation instruction for estimating the error

rate of the signal by the number of times of normalization counted in the count step; and a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

5   According to a seventh aspect of the present invention, there is provided an error rate estimating device for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates, the error rate

10   estimating device comprising a counting means for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates; an estimating means for estimating the error rate for each signal by

15   the number of times of normalization counted by the counting means; a multiplying means for determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating means for a predetermined transmission

20   system or coding rate among the transmission systems or coding rates and multiplying with that value; and an outputting means for adding and outputting the error rate for each signal output from the multiplying means.

       According to an eighth aspect of the present

25   invention, there is provided an error rate estimating

method for estimating an error rate of a signal when
decoding a signal modulated by a plurality of
transmission systems or coding rates, the error rate
estimating method comprising (1) a counting step of
counting the number of times of normalization, performed
when generating a state metric, for each of the plurality
of transmission systems or coding rates; (2) an
estimating step of estimating the error rate for each
signal by the number of times of normalization counted in
the counting step; (3) a multiplying step of determining
a value for multiplication with the error rate for each
signal according to a value of the error rate estimated
by the estimating step for a predetermined transmission
system or coding rate among the transmission systems or
coding rates and multiplying with that value; and (4) an
outputting step of adding and outputting the error rate
for each signal output in the multiplying step.

According to a ninth aspect of the present
invention, there is provided an information providing
medium for providing information for control executed by
a receiver receiving and decoding a signal modulated by a
plurality of transmission systems or coding rates sent
through a channel, the control information including a
count instruction for counting the number of times of
normalization, performed when generating a state metric,

for each of the plurality of transmission systems or

coding rates; an estimation instruction for estimating

the error rate for each signal by the number of times of

normalization counted in the counting step; a

5   multiplication instruction for determining a value for

multiplication with the error rate for each signal

according to a value of the error rate estimated by the

estimating step for a predetermined transmission system

or coding rate among the transmission systems or coding

10   rates and multiplying with that value; and an output

instruction for adding and outputting the error rate for

each signal output from the multiplying step.

According to a 10th aspect of the present invention,

there is provided a receiver for receiving and decoding a

15   signal which has been convolutionally coded, punctured,

and quadrature-modulated, the receiver provided with a

depuncturing means for performing processing reverse to

the puncturing and a decoding means for decoding the

above punctured quadrature-modulated data; the decoding

20   means having a branch metric calculating means for

calculating a branch metric of the above punctured

quadrature-modulated data, an adding, comparing, and

selecting means having an error estimating means for

estimating an error rate of a signal and adding and

25   comparing it for the calculated branch metric and for

selecting a path with reference to the result of

estimation by the error estimating means, and a path

memory for outputting a signal metric in accordance with

the path selected by the adding, comparing, and selecting

5   means; and the error rate estimating means is provided

with a counting means for counting the number of times of

normalization, performed when generating a state metric,

within a predetermined time and an estimating means for

estimating an error rate of the signal by the number of

10   times of normalization counted by the counting means.

According to an 11th aspect of the present

invention, there is provided a decoding method for

decoding a signal which has been convolutionally coded,

punctured, and quadrature-modulated, the decoding method

15   provided with (1) a depuncturing step for performing

processing reverse to the puncturing and (2) a decoding

step for decoding the above punctured

quadrature-modulated data; the decoding step comprising

(a) a step of calculating a branch metric of the above

20   punctured quadrature-modulated data, (b) a step of

estimating an error rate of a signal and adding and

comparing it for the calculated branch metric and for

selecting a path with reference to the estimated error

rate, and (c) a step of outputting a signal matrix in

25   accordance with the selected path; and the step of

estimating the error rate of the signal comprises (i) a

counting step of counting the number of times of

normalization, performed when generating a state metric,

within a predetermined time and (ii) an estimating step

5   of estimating an error rate of the signal by the number

of times of normalization counted by the counting step.

According to a 12th aspect of the present invention,

there is provided a receiver for receiving and decoding a

signal which has been convolutionally coded, punctured,

10   and quadrature-modulated, the receiver provided with a

depuncturing means for performing processing reverse to

the puncturing and a decoding means for decoding the

above punctured quadrature-modulated data; the decoding

means having a branch metric calculating means for

15   calculating a branch metric of the above punctured

quadrature-modulated data, an adding, comparing, and

selecting means having an error estimating means for

estimating an error rate of a signal and adding and

comparing it for the calculated branch metric and for

20   selecting a path with reference to the result of

estimation by the error estimating means, and a path

memory means for outputting a signal matrix in accordance

with the path selected by the adding, comparing, and

selecting means; and the error rate estimating means is

25   provided with a judging means for judging a transmission

system or coding rate of the signal; a counting means for

counting the number of times of normalization, performed

when generating a state metric, for each of the plurality

of transmission systems or coding rates; an estimating

5   means for estimating the error rate for each signal by

the number of times of normalization counted by the

counting means; and a selecting means for selecting one

of a plurality of error rates for each signal estimated

by the estimating means.

10   According to a 13th aspect of the present invention,

there is provided a decoding method for decoding a signal

which has been convolutionally coded, punctured, and

quadrature-modulated, the decoding method provided with

(1) a depuncturing step for performing processing reverse

15   to the puncturing and (2) a decoding step for decoding

the above punctured quadrature-modulated data; the

decoding step comprising (a) a step of calculating a

branch metric of the above punctured quadrature-modulated

data, (b) a step of estimating an error rate of a signal

20   and adding and comparing it for the calculated branch

metric and for selecting a path with reference to the

estimated error rate, and (c) a step of outputting a

signal matrix in accordance with the selected path; and

the error rate estimating step of estimating the error

25   rate comprises (i) a judging step of judging a

transmission system or coding rate of the signal; (ii) a

counting step of counting the number of times of

normalization, performed when a state metric is

generated, for each of the plurality of transmission

5   systems or coding rates; (iii) an estimating step of

estimating the error rate for each signal by the number

of times of normalization counted in the counting step;

and (iv) a selecting step of selecting one of a plurality

of error rates for each signal estimated in the

10   estimating step.

According to a 14th aspect of the present invention,

there is provided a receiver for receiving and decoding a

signal which has been convolutionally coded, punctured,

and modulated by a plurality of coding systems or coding

15   rates, the receiver provided with a depuncturing means

for performing processing reverse to the puncturing and a

decoding means for decoding the above punctured

quadrature-modulated data; the decoding means having a

branch metric calculating means for calculating a branch

20   metric of the above punctured quadrature-modulated data,

an adding, comparing, and selecting means having an error

estimating means for estimating an error rate of a signal

and adding and comparing it for the calculated branch

metric and for selecting a path with reference to the

25   result of estimation by the error estimating means, and a

path memory means for outputting a signal matrix in

accordance with the path selected by the adding,

comparing, and selecting means; and the error rate

estimating means is provided with a counting means for

5   counting the number of times of normalization, performed

when generating a state metric, within a predetermined

time, an estimating means for estimating the error rate

of the signal by the number of times of normalization

counted by the counting means, and a multiplying means

10   for determining a value for multiplication with the error

rate for each signal according to a value of the error

rate estimated by the estimating means for a

predetermined transmission system or coding rate among

the transmission systems or coding rates and multiplying

15   with that value, and an outputting means for adding and

outputting the error rate for each signal output from the

multiplying means.

      According to a 15th aspect of the present invention,

there is provided a decoding method for decoding a signal

20   which has been convolutionally coded, punctured, and

modulated by a plurality of modulation systems or coding

rates, the decoding method provided with (1) a

depuncturing step for performing processing reverse to

the puncturing and (2) a decoding step for decoding the

25   above punctured quadrature-modulated data; the decoding

step comprising (a) a step of calculating a branch metric

of the above punctured quadrature-modulated data, (b) a

step of estimating an error rate of a signal and adding

and comparing it for the calculated branch metric and for

5   selecting a path with reference to the estimated error

rate, and (c) a step of outputting a signal matrix in

accordance with the selected path; and the step of

estimating the error rate of the signal comprises (i) a

counting step of counting the number of times of

10   normalization, performed when generating a state metric,

for each of a plurality of transmission systems or coding

rates, (ii) an estimating step of estimating an error

rate for each signal by the number of times of

normalization counted by the counting step, (iii) a

15   multiplying step of determining a value for

multiplication with the error rate for each signal

according to a value of the error rate estimated by the

estimating step for a predetermined transmission system

or coding rate among the transmission systems or coding

20   rates and multiplying with that value, and (iv) an

outputting step of adding and outputting the error rate

for each signal output in the multiplying step.

BRIEF DESCRIPTION OF THE DRAWINGS

25   Figure 1 is a block diagram of the configuration of

a transmitter and a receiver.

Figure 2 is a block diagram of the configuration of the encoder of Fig. 1.

Figures 3A and 3B are views for explaining a puncturing unit of Fig. 1.

Figures 4A and 4B are views for explaining the input/output data of the puncturing unit.

Figure 5 is a view for explaining the arrangement of signal points by the mapping unit of Fig. 1.

Figures 6A and 6B are views for explaining a bit insertion unit of Fig. 1.

Figures 7A and 7B are views for explaining the input/output data of the bit insertion unit.

Figure 8 is a block diagram of the configuration of the decoder of Fig. 1.

Figure 9 is a trellis diagram.

Figure 10 is a block diagram of the configuration of the ACS circuit of Fig. 8.

Figure 11 is a block diagram of the configuration of an ACS circuit performing normalization.

Figure 12 is a block diagram of the configuration of the monitoring circuit of Fig. 8.

Figure 13 is a block diagram of the configuration of the accumulator of Fig. 12.

Figures 14A to 14D are timing charts for explaining

an operation of the accumulator of Fig. 13.

Figures 15A and 15B are views of a table stored in the table of Fig. 12.

Figure 16 is a block diagram of the configuration of the ACS circuit of the present invention.

Figure 17 is a block diagram of the configuration of the monitoring circuit to which the present invention is applied.

Figure 18 is a block diagram of the configuration of a normalization accumulator in Fig. 17.

Figures 19A to 19D are timing charts for explaining the operation of the normalization accumulator in Fig. 18.

Figures 20A and 20B are views of a table stored in the table of Fig. 17.

Figures 21A and 21B are views of a table stored in the table of Fig. 17.

Figure 22 is a block diagram of another configuration of the monitoring circuit.

Figure 23 is a graph illustrating the function of the function processor of Fig. 22.

Figure 24 is a view for explaining a frame structure of a different coding rate.

Figure 25 is a view for explaining another configuration of the decoder.

Figure 26 is a block diagram of the configuration of the monitoring circuit of Fig. 25.

Figure 27 is a block diagram of the configuration of the normalization accumulator of Fig. 26.

5   Figures 28A to 28F are timing charts for explaining an operation of the normalization accumulator of Fig. 27.

Figure 29 is a block diagram of another example of the configuration of the monitoring circuit.

Figure 30 is a block diagram of still another

10   example of the configuration of the monitoring circuit.

Figure 31 is a view of the configuration of the selector of Fig. 30.

Figure 32 is a view of the configuration of the selector of Fig. 30.

15   Figure 33 is a view of a table stored in the selector of Fig. 30.

Figure 34 is a view of a table stored in the selector of Fig. 30.

Figure 35 is a block diagram of the configuration of

20   the monitoring circuit and the receiver when simultaneously receiving signals of different coding rates.

Figure 36 is a block diagram of the configuration of the monitoring circuit of Fig. 35.

25   Figure 37 is a view of a table stored in the

selector of Fig. 36.

Figure 38 is a view explaining the hardware
configuration when realizing the coding processing by
software.

5   Figure 39 is a view explaining the hardware
configuration when realizing the decoding processing by
software.

BEST MODE FOR CARRYING OUT THE INVENTION

10   A transmitter and receiver to which the present
invention is applied are basically configured the same as
in the configuration shown in Fig. 1, therefore
explanations thereof are omitted. The method of judging
the error rate on the channel performed at the receiver

15   side in the present invention differs from that explained
above. First, the configuration of the ACS circuit 32 of
the decoder 9 will be explained with reference to Fig.
16.

Figure 16 is a block diagram of the configuration of

20   the ACS circuit 32 for performing normalization using the
data of the upper bits of the state metrics of all states
to find a state metric. The most significant bit of the N
number of bits of data output from the state 00
generating unit 41 for generating the state metric of the

25   state 00 is input to the register 48-1 through an EXOR

(exclusive OR) circuit 81-1 for calculating the exclusive OR. The N-1 number of bits other than the most significant bit are input to the register 48-1 without going through the EXOR circuit 81-1. Data from the AND circuit 82 for calculating the AND is input to the EXOR circuit 81-1 as well. Data output from the register 48-1 is supplied to the path memory 33, while the most significant bit is supplied to the AND circuit 82.

In the same way, the most significant bit among the N number of bits of data output from the state 01 generating unit 42 is input to the register 48-2 through the EXOR circuit 81-2, while the N-1 number of bits other than the most significant bit are input to the register 48-2 without going through the EXOR circuit 81-2. Data from the AND circuit 82 is input to the EXOR circuit 81-2. Data output from the register 48-2 is supplied to the path memory 33, while the most significant bit is supplied to the AND circuit 82.

In addition, the most significant bit of the N number of bits of data output from the state 10 generating unit 43 is input to the register 48-3 through the EXOR circuit 81-3, while the N-1 number of bits other than the most significant bit are input to the register 48-3 without going through the EXOR circuit 81-3. Data from the AND circuit 82 is input to the EXOR circuit 81-3

as well. Data output from the register 48-3 is supplied
to the path memory 33, while the most significant bit is
supplied to the AND circuit 82.

Further, the most significant bit of the N number of

5   bits of data output from the state 11 generating unit 44
is input to the register 48-4 through the EXOR circuit,
while the N-1 number of bits other than the most
significant bit is input to the register 48-4 without
going through the EXOR circuit. Data output from the AND

10   circuit 82 is input to the EXOR circuit 81-4 as well.
Data output from the register 48-4 is supplied to the
path memory 33, and the most significant bit is supplied
to the AND circuit 82.

The AND circuit 82 outputs 1 when all of the most

15   significant bits of data output from the registers 48-1
to 48-4 are 1 and outputs 0 at other times. When the
values of the state metrics of the states gradually
increase and the most significant bit of the minimum
state metric becomes 1, it uses an exclusive OR operation

20   (EXOR circuits 81-1 to 81-4) to make the most significant
bits of the state metrics of all states 0 for
normalization.

Figure 17 is a block diagram of the configuration of
the monitoring circuit 11. The monitoring circuit 11 is

25   comprised of a normalization accumulator 91 and a table

92. The normalization information is input from the ACS

circuit 32 to the normalization accumulator 91. The

normalization information is information output to the

monitoring circuit 11 each time the normalization is

5   performed by the ACS circuit 32.

Figure 18 is a block diagram of the configuration of

the normalization accumulator 91. The normalization

accumulator 91 is comprised of a timer 101, a

normalization cumulative counter 102, and a register 103.

10   Normalization information output from the ACS circuit 32

is input to the normalization cumulative counter 102. A

pulse generated by the timer 101 every predetermined time

is input to the normalization cumulative counter 102 as

well. The pulse generated by the timer 101 is output to

15   the register 103 as well. The output from the

normalization cumulative counter 102 is input to the

register 103 as well.

The operation of the normalization accumulator 91

shown in Fig. 18 will be explained referring to the

20   timing chart in Figs. 19A to 19D. As shown in Fig. 19A, a

pulse is generated for every time unit by the timer 101,

and the generated pulse is supplied to the normalization

cumulative counter 102 and the register 103. As shown in

Fig. 19B, the normalization cumulative counter 102 counts

25   the number of times of input when the normalization

information is output from the ACS circuit 32. In the example shown in Figs. 19A to 19D, eight times of normalization information are input during one time unit.

The normalization cumulative counter 102 outputs the
5   counter value to the register 103 and resets its value to 0 (Fig. 19D) for every pulse supplied from the timer 101. In this way, the counter value output to and stored in the register 103 is output to the table 92 when the pulse from the timer 101 is input.

10   Figures 20A and 20B are views of examples of tables stored by the table 92. The table shown in Figs. 20A and 20B shows the correspondence between the counter value (count) output from the register 103 of the normalization accumulator 91 and the value of the transmission error
15   rate (BER: bit error rate) of the channel 6 estimated from the count. Figure 20A is a table in the case where the transmission system is the QPSK system and the coding rate R is 1/2, while Fig. 20B is a table in the case where the transmission system is the QPSK system and the
20   coding rate R is 3/4.

For instance, in the case where the transmission system is the QPSK system and the coding rate R is 1/2, when the count supplied from the register 103 is 355 or more, the value output as the error rate information 12
25   of the channel 6 (Fig. 1) is 0.50 x 10^{-3}. In the same

way, a value calculated based on the table from the transmission system, coding rate, and a value corresponding to the count is output as the error rate information 12.

5   . Figures 21A and 21B show tables in the case where the CN ratio (carrier to noise ratio) is output as the error rate information 12. Figure 21A is a table when the transmission system is the QPSK system and the coding rate R is 1/2, while Fig. 21B is a table when the

10   transmission system is the QPSK system and the coding rate R is 3/4. For instance, in the case where the transmission system is the QPSK system and the coding rate R is 1/2, when the count supplied from the register 103 is 355 or more, the value output as the error rate

15   information 12 of the channel 6 is 3.00 (dB).

         Figure 22 is a block diagram of another configuration of the monitoring circuit 11. The monitoring circuit 11 shown in Fig. 22 is comprised of the normalization accumulator 91 and a function processor

20   111. The function processor 111 estimates the error rate information 12 without using the tables shown in Figs. 20A and 20B and Figs. 21A and 21B, but by using the function f calculated from these tables.

         In the table shown in Fig. 20A in the case where the

25   transmission system is the QPSK system and the coding

rate R is 1/2, BER is 1.09 x 10^{-3} when the count is from 345 to 354 (representative value of 350) and BER is 0.80 x 10^{-2} when the count is from 335 to 344 (representative value of 340). In the other words, it is learned that if

5 the count is reduced by 10 from 350 to 340, the value of BER increases by about four times. Calculating the equation used in the function processor 111 considering this fact gives the following equation (1):

$$f(input)=0.0005 \text{ x } 4^{((360-input)/10)} \qquad (1)$$

10 In equation (1), the above "input" shows the count input from the normalization accumulator 91.

Note that in equation (1), the range of the count able to be used as input is from 335 to 354. When the count is 334 or less, 0.2 x 10^{-1} is output as the error

15 rate information 12, while when the count is 355 or more, 0.5 x 10^{-3} is output as the error rate information 12.

This is because a difference arises between the value obtained from the function f and the value used when preparing a table (function f no longer followed).

20 In this way, in the practical range, the function f is used in the range where there is no problem, while a value based on the count is output in other ranges.

In the same way, the following equation (2) is derived as a function f corresponding to the table of

25 Fig. 20B in the case where the transmission system is the

QPSK system and the coding rate is 3/4:

$$f(\text{input}) = 0.0033 \times 3^{((580-\text{input})/10)} \qquad (2)$$

In equation (2), the range of the count able to be used

as the input is 545 to 565. When the count is 544 or

5   less, 1.90×10^{-1} is output as the error rate information

12, while when the count 565 or more, 4.80×10^{-3} is

output as the error rate information 12.

The following equation (3) is derived as a function

f corresponding to the table shown in Fig. 21A in the

10   case where the transmission system is the QPSK system and

the coding rate is 1/2.

$$f(\text{input}) = 0.05^{(\text{input}-300)} \qquad (3)$$

In equation (3), the range of the count able to be used

as the input is 335 to 355. When the count is 334 or

15   less, 1.50 is output as the error rate information 12,

while when the count is 355 or more, 3.00 is output as

the error rate information 12.

The following equation (4) is derived as a function

f corresponding to the table shown in Fig. 21B in the

20   case where the transmission system is the QPSK system and

the coding rate is 3/4.

$$f(\text{input}) = 0.025^{(\text{input}-500)} \qquad (4)$$

In equation (4), the range of the count able to be used

as the input is 544 to 565. When the count is 544 or

25   less, 0.85 is output as the error rate information 12,

while when the count is 565 or more, 2.20 is output as the error rate information 12.

Figure 23 shows the relation between data serving as the basis when preparing a table and a graph obtained by any one equation among equations (1) to (4). As will be understood from Fig. 23, equations (1) to (4) approximate the values of the table within the dotted lines. Outside of the dotted lines, since the equations do not approximate to the values of the table, as described above, the error rate information 12 is not obtained using equations (1) to (4), but a predetermined value is output. Note that in practice, if the BER or C/N value obtained by equations (1) to (4) is sufficient, it is possible not to output the error rate information 12 outside the range obtained by equations (1) to (4).

In the above explanation, the case where the transmission system was the QPSK system and the coding rate R was either of 1/2 or 3/4 was explained, but different transmission systems or coding rates R are mixed in some cases. For example, as shown in Fig. 24, the following explanation will be given taking as an example the case where the transmission system is the QPSK system, but the coding rate R is a mixture of 1/2 and 3/4.

Figure 25 is a block diagram of the configuration of

the decoder 9 and the monitoring circuit 11 in the case

where different coding rates R are mixed together. In

this configuration, the monitoring circuit 11 receives as

input information relating to the coding rate R from the

5   bit insertion unit 8 (Fig. 1). The bit insertion unit 8

judges the coding rate R, outputs a signal as is to the

decoder 9 when a signal of a coding rate R of 1/2 is

input, and inserts bits by depuncturing and then outputs

the signal to the decoder 9 when a signal of a coding

10   rate R of 3/4 is input. The monitoring circuit 11

receives as input information of the judged coding rate

R.

Figure 26 is a block diagram of the configuration

of the monitoring circuit 11 shown in Fig. 25. The

15   normalization accumulator 91 in this configuration

receives as input the normalization information from the

ACS circuit 32 and the coding rate information from the

bit insertion unit 8.

Figure 27 is a block diagram of the configuration of

20   the normalization accumulator 91 shown in Fig. 26. In

this configuration, the timer 101 and the normalization

cumulative counter 102 receive as input the coding rate

information. The normalization cumulative counter 102

also receives as input the normalization information and

25   the pulses output from the timer 101. The register 103

receives as input the output from the normalization cumulative counter 102 and the pulses from the timer 101.

The operation of the normalization accumulator 91 shown in Figs. 28A to 28F will be explained next referring to the timing chart of Fig. 27. The explanation will be made of the case where the transmission system is the QPSK system, but the coding rate R is changed in the order of 1/2, 3/4, and 1/2 as shown Fig. 28A and the case where a pulse is generated at the timer 101 as shown in Fig. 28B. The interval between the pulse generated at the timer 101 at a predetermined time and the pulse the next time is defined as one time unit.

Here, for instance, if the coding rate information is made 1 when the coding rate R is 1/2 and is made 0 when the coding rate R is 3/4, when the coding rate R changes as shown in Fig. 28A, the coding rate information becomes as shown in Fig. 28C. Further, as shown in Fig. 28D, when the normalization information is input a total of eight times in a time unit, that is, six times when the coding rate R is 1/2 and two times when the coding rate R is 3/4, in the normalization cumulative counter 102, the normalization cumulative counter 102 counts only the number of times of normalization at the same coding rate R, in the other words, only the number of times of normalization when the coding rate information is 1.

That is, in the example shown in Fig. 28E, only the number of times of normalization when the coding rate R is 1/2 is counted, so the value output to the table 92 from the register 103 as the number of times of

5   normalization number for one time unit becomes six.

The table 92 uses the value input in this way and the stored table to calculate and output the error rate information 12. As the tables which the table 92 stores, the table shown in Figs. 20A and 20B or the table shown

10   in Figs. 21A and 21B may be used. Further, it is possible to find the error rate information 12 from the function f.

Figure 29 is a block diagram of another configuration of the monitoring circuit 11 for estimating

15   the error rate information 12 when different transmission systems or coding rates R are mixed together. In this configuration, the error rate information 12 is estimated separately for the signals with the coding rate R of 1/2 and the signals with the coding rate R of 3/4. A

20   normalization accumulator 91-1 and a normalization accumulator 91-2 receive as input normalization information from the ACS circuit 32. The coding rate information from the bit insertion unit 8 is supplied to the normalization accumulator 91-2 and the selector 122

25   and is also supplied to the normalization accumulator

91-1 through a NOT circuit 121. The coding rate

information input to the normalization accumulator 91-1

is input through the NOT circuit 121, so information

opposite to that of the normalization accumulator 91-2 is

5   input.

The information output from the normalization

accumulator 91-1 is input to the table 92-1, while the

information output from the normalization accumulator

91-2 is input to the table 92-2. The information output

10   from the table 92-1 and table 92-2 is input to the

selector 122. The selector 122 selects and outputs one of

the information input from the tables 92-1 and 92-2 based

on the input coding information.

The normalization accumulator 91-1 and the

15   normalization accumulator 91-2 are configured as shown in

Fig. 12. The normalization accumulator 91-1 counts the

number of times of normalization input when the coding

rate information is of the coding rate R of 1/2, while

the normalization accumulator 91-2 counts the number of

20   times of normalization input when the coding rate

information is of the coding rate R of 3/4. As explained

above, since the mutually opposite coding rate

information input to the normalization accumulator 91-1

and the normalization accumulator 91-2 are input, when

25   one of the number of times of normalization is being

counted, the other is not counted.

The numbers of times of normalization counted by the normalization accumulators 91-1 and 91-2 in this way are output to the corresponding tables 92-1 and 92-2. The

5 table 92-1 stores the tables shown in Fig. 20A and Fig. 21A, while the table 92-2 stores the tables shown in Fig. 20B and Fig. 21B. The tables 92-1 and 92-2 estimate the error rate information 12 according to the tables they store and output the results to the selector 122. The

10 selector 122 selects the input from the tables 92-1 and 92-2 corresponding to the coding rate which the input coding rate information indicates and outputs the same as the error rate information 12.

Figure 30 is a block diagram of another

15 configuration of the monitoring circuit 11. The selector 131 of this configuration selects and outputs an input from the tables 92-1 and 92-2 without using the coding information. The configuration of the selector 131 is shown in Fig. 31. The selector 131 stores the constant C.

20 This constant C and the input value are compared to determine the output information. That is, when the input 0 is made the input from the table 92-1 and the input 1 is made the input from the table 92-2, the input O is output as the error rate information 12 if input O is

25 larger than the constant C, while the input 1 is output

as the error rate information 12 if the input O is equal
to or less than the constant C.

Figure 32 is a block diagram of another
configuration of the selector 131. The selector 131
5   outputs a value giving a predetermined weight to the
input value. the multiplier 141-1 receives as input
information from the table 92-1, while the multiplier
141-2 receives as input the information from the table
92-2. The multipliers 141-1 and 141-2 multiply the values
10   input to them with a predetermined value and output the
results to an adder 142. The adder 142 adds and outputs
the sum of the input values.

Figure 33 is a table showing weighting values to be
multiplied by the multipliers 141-1 and 141-2. The table
15   is stored in a not shown storage unit and is supplied to
the multipliers 141-1 and 141-2 of the selector 131 in
accordance with need. The table is a table corresponding
to the table shown in Figs. 21A and 21B. The value for
the weighting is determined based on the error rate
20   information 12 of the coding rate R=1/2 (information
output from the table 91-1). For instance, when
information from the table 92-1 input to the multiplier
141-1 is 2.5, 1.0 is supplied as the weighting value to
the multiplier 141-1 and 0.0 is supplied as the weighting
25   value to the multiplier 141-2.

Figure 34 is another table of the weighting values. The table is a table for the case of weighting based on the information of the cumulative number of times of normalization when the coding rate R=3/4. When weighting in accordance with the table, the multipliers 141-1 and 141-2 (Fig. 32) are supplied with output from the normalization accumulator 91-2. The multipliers 141-1 and 141-2 weight the values input from the tables 92-1 and 92-2 based on the input normalization information and output the results. For example, when the information of the cumulative number of times of normalization output from the normalization accumulator 91-2 is 570, the multiplier 141-1 multiplies 0.0 with the value input from the table 92-1 by 0.0, the multiplier 141-2 multiplies 1.0 with the value input from the table 92-2, and these output the results to the adder 142.

In the above explanation, the tables 92-1 and 92-2 estimated the error rate information 12 from the stored tables, but it is also possible to estimate this using the above functions. Namely, it is also possible to use a function processor using the function of equation (3) instead of the table 92-1 and use a function processor using a function of equation (2) instead of the table 92-2.

Next, a monitoring circuit 11 in the case of

simultaneously receiving and processing two or more

signals transmitted by different transmission systems

(coding rates) will be explained. Figure 35 is a block

diagram of the configuration of a receiver including a

5   monitoring circuit 11 which simultaneously receives and

processes two or more signals transmitted by different

transmission systems. The monitoring circuit 11 receives

as input normalization information from the decoders 9

and 9'.

10   Figure 36 is a block diagram of the configuration of

the monitoring circuit 11 of Fig. 35. The normalization

accumulator 91-1 receives as input the normalization

information of the encoder 9, while the normalization

accumulator 91-2 receives as input the normalization

15   information of the coder 9'. The information output from

the normalization accumulator 91-1 is input to the table

92-1, while the information output from the normalization

accumulator 91-2 is input to the table 92-2. The

information output from the tables 92-1 and 92-2 are

20   input to the selector 131.

The normalization accumulators 91-1 and 91-2 are

configured is shown in Fig. 3. The normalization

accumulator 91-1 cumulatively adds the number of times of

normalization for a signal of a coding rate R of 1/2,

25   while the normalization accumulator 91-2 cumulatively

adds the number of times of normalization of a signal of a coding rate R of 3/4. The table 92-1 stores the table of Fig. 21A, while the table 92-2 stores the table of Fig. 21B. The selector 131 is configured as shown in Fig. 32, stores the table shown in Fig. 37, weights the input value based on the stored table, and outputs the result.

The table shown in Fig. 37 shows a table in the case of weighting based on an estimated value of the error rate information 12 for a coding rate R=3/4 (information output from the table 92-2). For instance, when the estimated value output from the table 92-2 is 2.5, the selector 131 multiplies 1.0 with the estimated value input from the table 92-1 based on the table shown in Fig. 37, multiplies <u>0.0</u> with the estimated value input from the table 92-2, adds the values, and outputs the result.

As described above, since the error rate on the channel is calculated based on the number of times of normalization performed in the ACS circuit 32 for finding the state metric, the circuit can be made smaller and simpler. It is also possible to properly estimate the error rate information for a signal transmitted by different transmission systems or coding rates.

Next, an explanation will be given, using Fig. 38,

of the hardware configuration of the transmitter 1 in the case of coding processing explained using Fig. 1 to Fig. 37 by software.

In Fig. 38, the transmitter 1 is provided with a CPU

5 (central processing unit) 1001 for executing a processing program, a ROM (read only memory) 1002 storing a processing program for processing in accordance with a coding routine explained using Fig. 1 to Fig. 37, a RAM (random access memory) 1003 temporarily storing

10 processing data, an external storage 1004 storing data to be coded and transmitted, and a communications I/F (interface) 1005 for transmitting an I-signal and Q-signal of a signal point through the channel 6 to the receiver 7. Further, it is provided with a path 1006

15 connected to the circuits for transmission of the program or data.

The external storage 1004 is a randomly accessible information storage medium such as a magnetic disk or optical disk.

20 Note that the processing program of the present embodiment is stored in the ROM 1002 in this configuration, but it is also possible to have it stored in an external storage 1004 and to transfer it through the bus 1006 to the RAM 1003 at the time of execution and

25 execute it by the CPU 1001. Further, it is also possible

to configure the communications I/F 1005 to be able to transmit and receive a signal, have the processing program received by the communications I/F 1005 from the external storage through the channel, store it in the RAM

5 1003 or the external storage 1004, and execute it at the CPU 1001.

That is, the transmitter 1 may introduce the computer program for the above processing for processing at the CPU 1001 through not only a medium comprised of a

10 magnetic disk, CD-ROM, or other information storage medium, but also the Internet, digital satellite, or other transmission medium.

An explanation will be given, using Fig. 39, of the hardware configuration of the receiver 1 in the case of

15 decoding processing explained using Fig. 1 to Fig. 37 by software.

In Fig. 39, the receiver 7 is provided with a CPU (central processing unit) 2001 for executing a processing program, a ROM (read only memory) 2002 storing a

20 processing program for processing in accordance with a decoding routine explained using Fig. 1 to Fig. 37, a RAM (random access memory) 2003 temporarily storing processing data, an external storage 2004 storing data to be decoded, that is, decoding information 10, and a

25 communications I/F (interface) 2005 for receiving an I-

signal and Q-signal from the transmitter 1 through the

channel 6. Further, it is provided with a path 2006

connected to the circuits for transmission of the program

or data.

5   The external storage 2004 is a randomly accessible

information storage medium such as a magnetic disk or

optical disk.

Note that the processing program of the present

embodiment is stored in the ROM 2002 in this

10   configuration, but it is also possible to have it stored

in an external storage 2004 and to transfer it through

the bus 2006 to the RAM 2003 at the time of execution and

execute it by the CPU 2001. Further, it is also possible

to configure the communications I/F 2005 to be able to

15   transmit and receive a signal, have the processing

program received by the communications I/F 2005 from the

external storage through the channel, store it in the RAM

2003 or the external storage 2004, and execute it at the

CPU 2001.

20   That is, the receiver 7 may introduce the computer

program for the above processing for processing at the

CPU 2001 through not only a medium comprised of a

magnetic disk, CD-ROM, or other information storage

medium, but also the Internet, digital satellite, or

25   other transmission medium.

As explained above, according to the above embodiment using the error rate estimating device, the error rate estimating method, and the medium of the present invention, since the number of times of

5   normalization performed when generating a state metric is counted within a predetermined time and the error rate of a signal is estimated by the counted number of times of normalization, the device for estimating the error rate of the signal can be made smaller in configuration and

10   can perform processing at a high speed.

Further, according to the above embodiment using the error rate estimating device, the error rate estimating method, and the medium of the present invention, since the number of times of normalization performed when

15   generating a state metric is counted for each of a plurality of transmission systems or coding rates and the error rate for each signal is estimated by the counted number of times of normalization, the device for estimating the error rate of the signal can be made

20   smaller in configuration and can perform processing at a high speed.

Further, according to the above embodiment utilizing the error rate estimating device, error rate estimating method, and medium of the present invention, since the

25   number of times of normalization performed when

generating a state metric is counted for each of a

plurality of transmission systems or coding rates, the

error rate for each signal is estimated by the counted

number of times of normalization, a value to be

5 multiplied with an error rate for each signal is

determined in accordance with the value of the error rate

estimated by the estimating means for a predetermined

transmission system or coding rate and multiplied, and

the value is added and output, the device for estimating

10 the error rate of the signal can be made smaller in

configuration and can perform processing at a high speed.

INDUSTRIAL APPLICABILITY

The error rate estimating device and the error rate

estimating method of the present invention may be applied

15 to various apparatuses for transmitting signals.

CLAIMS

1.   An error rate estimating device for estimating

the error rate of an quadrature-modulated signal when

decoding the signal,

5   the error rate estimating device provided with

counting means ~~(91, 101, 102, 103)~~ for counting

the number of times of normalization, performed when

generating a state metric within a predetermined time and

an estimating means (92, 111) for estimating

10   the error rate of the signal by the number of times of

normalization counted by the counting means.

2.   An error rate estimating device as set forth in

claim 1, wherein the estimating means estimates the error

rate based on a table establishing correspondence between

15   the number of times of normalization and the error rate

on a channel.

3.   An error rate estimating device as set forth in

claim 1, wherein the estimating means inserts the number

of times of normalization counted by the counting means

20   into a predetermined function.

4.   An error rate estimating device as set forth in

claim 1, wherein the counting means counts only the

number of times of normalization for a signal of a

predetermined transmission system or a predetermined

25   coding rate.

5. An error rate estimating method for estimating
an error rate of a signal when decoding an
quadrature-modulated signal,

said error rate estimating method comprising:

5 a counting step of counting the number of times
of normalization, performed when generating a state
metric, within a predetermined time and

an estimating step of estimating the error rate
of the signal by the number of times of normalization
10 counted in the counting step.

6. An error rate estimating method as set forth in
claim 5, wherein in the estimating step, the error rate
is estimated based on a table establishing correspondence
between the number of times of normalization and the
15 error rate on a channel.

7. An error rate estimating method as set forth in
claim 5, wherein in the estimating step, the number of
times of normalization counted in the counting step is
inserted into a predetermined function.

20 8. An error rate estimating method as set forth in
claim 5, wherein in the counting step, only the number of
times of normalization for a signal of a predetermined
transmission system or a predetermined coding rate is
counted.

25 9. An information providing medium for providing

information for control executed by a receiver receiving

and decoding an quadrature-modulated signal transmitted

through a channel, wherein said control information

includes:

5   a count instruction for counting the number of

times of normalization, performed when generating a state

metric, within a predetermined time and

        an estimation instruction for estimating the

error rate of the signal by the number of times of

10 normalization counted when said count instruction is

executed.

     10. An information providing medium as set forth in

claim 9, wherein the estimation instruction estimates the

error rate based on a table establishing correspondence

15 between the number of times of normalization and the

error rate on a channel.

     11. An information providing medium as set forth in

claim 9, wherein the estimation instruction inserts the

number of times of normalization counted by the counting

20 means into a predetermined function.

     12. An information providing medium as set forth in

claim 9, wherein the count instruction counts only the

number of times of normalization for a signal of a

predetermined transmission system or a predetermined

25 coding rate.

13.   An error rate estimating device for estimating

an error rate of a signal when decoding a signal

modulated by a plurality of transmission systems or

coding rates,

5   said error rate estimating device provided

with:

          a judging means (62) for judging a transmission

system or coding rate of the signal;

          a counting means (91) for counting the number

10   of times of normalization, performed when generating a

state metric, for each of the plurality of transmission

systems or coding rates;

          an estimating means (92, 111) for estimating

the error rate for each signal by the number of times of

15   normalization counted by the counting means; and

          a selecting means (32, 33) for selecting one of

a plurality of error rates for each signal estimated by

the estimating means.

          14.   An error rate estimating device as set forth in

20   claim 13, wherein said selecting means selects the error

rate according to the transmission system or the coding

rate judged by the judging means.

          15.   An error rate estimating device as set forth in

claim 13, wherein the selecting means selects an error

25   rate to be output by comparing a plurality of error rates

input with a predetermined reference value.

16. An error rate estimating method for estimating an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or
5 coding rates, said error rate estimating method comprising:

a judging step of judging a transmission system or coding rate of the signal;

a counting step of counting the number of times
10 of normalization, performed when a state metric is generated, for each of the plurality of transmission systems or coding rates;

an estimating step of estimating the error rate for each signal by the number of times of normalization
15 counted in the counting step; and

a selecting step of selecting one of a plurality of error rates for each signal estimated in the estimating step.

17. An error rate estimating method as set forth in
20 claim 16, further comprising, in said selecting step, selecting the error rate according to the transmission system or the coding rate judged by the judging step.

18. An error rate estimating method as set forth in claim 16, further comprising, in said selecting step,
25 selecting an error rate to be output by comparing a

plurality of error rates input with a predetermined reference value.

19. An information providing medium for providing information for control executed by a receiver receiving

5   a signal modulated by a plurality of transmission systems or coding rates sent through a channel, wherein said control information includes:

a judgement instruction for judging a transmission system or coding rate of the signal;

10   a count instruction for counting the number of times of normalization, performed when generating a state metric, within a predetermined time;

an estimation instruction for estimating the error rate of the signal by the number of times of normalization counted in said count step; and

15   a selection instruction for selecting one of a plurality of error rates for each signal estimated in the estimating step.

20. An error rate estimating device for estimating

20   an error rate of a signal when decoding a signal modulated by a plurality of transmission systems or coding rates,

said error rate estimating device comprising:

a counting means (91) for counting the number

25   of times of normalization, performed when generating a

state metric, for each of the plurality of transmission

systems or coding rates;

an estimating means (92) for estimating the

error rate for each signal by the number of times of

5   normalization counted by the counting means;

a multiplying means (111) for determining a

value for multiplication with the error rate for each

signal according to a value of the error rate estimated

by the estimating means for a predetermined transmission

10   system or coding rate among the transmission systems or

coding rates and multiplying with that value; and

an outputting means (32, 33) for adding and

outputting the error rate for each signal output from the

multiplying means.

15   21.   An error rate estimating method for estimating

an error rate of a signal when decoding a signal

modulated by a plurality of transmission systems or

coding rates,

said error rate estimating method comprising:

20   a counting step of counting the number of times

of normalization, performed when generating a state

metric, for each of the plurality of transmission systems

or coding rates;

an estimating step of estimating the error rate

25   for each signal by the number of times of normalization

counted in the counting step;

a multiplying step of determining a value for multiplication with the error rate for each signal according to a value of the error rate estimated by the estimating step for a predetermined transmission system or coding rate among the transmission systems or coding rates and multiplying with that value; and

an outputting step of adding and outputting the error rate for each signal output in the multiplying step.

22. An information providing medium for providing information for control executed by a receiver receiving and decoding a signal modulated by a plurality of transmission systems or coding rates sent through a channel,

said control information including:

a count instruction for counting the number of times of normalization, performed when generating a state metric, for each of the plurality of transmission systems or coding rates;

an estimation instruction for estimating the error rate for each signal by the number of times of normalization counted in the counting step;

a multiplication instruction for determining a value for multiplication with the error rate for each

signal according to a value of the error rate estimated

by the estimating step for a predetermined transmission

system or coding rate among the transmission systems or

coding rates and multiplying with that value; and

5　　　　　an output instruction for adding and outputting

the error rate for each signal output from the

multiplying step.

　　　　23.　A receiver (6) for receiving and decoding a

signal which has been convolutionally coded, punctured,

10　and quadrature-modulated,

　　　　　said receiver provided with:

　　　　　a depuncturing means (8) for performing

processing reverse to said puncturing and

　　　　　a decoding means (9) for decoding the above

15　punctured quadrature-modulated data;

　　　　　said decoding means having

　　　　　a branch metric calculating means (31) for

calculating a branch metric of the above punctured

quadrature-modulated data,

20　　　　　an adding, comparing, and selecting means (32,

11) having an error estimating means (11) for estimating

an error rate of a signal and adding and comparing it for

the calculated branch metric and for selecting a path

with reference to the result of estimation by the error

25　estimating means, and

a path memory (33) for outputting a signal

matrix in accordance with the path selected by said

adding, comparing, and selecting means; and

said error rate estimating means (11) is

5 provided with:

a counting means (91) for counting the number

of times of normalization, performed when generating a

state metric, within a predetermined time and

an estimating means (92, 111) for estimating an

10 error rate of said signal by the number of times of

normalization counted by said counting means.

24. A receiver as set forth in claim 23, wherein

the estimating means estimates the error rate based on a

table establishing correspondence between the number of

15 times of normalization and the error rate on a channel.

25. A receiver as set forth in claim 23, wherein

the estimating means inserts the number of times of

normalization counted by the counting means into a

predetermined function.

20 26. A receiver as set forth in claim 23, wherein

the counting means counts only the number of times of

normalization for a signal of a predetermined

transmission system or a predetermined coding rate.

27. A decoding method for decoding a signal which

25 has been convolutionally coded, punctured, and

quadrature-modulated,

said decoding method provided with:

a depuncturing step for performing processing

reverse to said puncturing and

5   a decoding step for decoding the above

punctured quadrature-modulated data;

said decoding step comprising

a step of calculating a branch metric of the

above punctured quadrature-modulated data,

10   a step of estimating an error rate of a signal

and adding and comparing it for the calculated branch

metric and for selecting a path with reference to the

estimated error rate, and

a step of outputting a signal matrix in

15 accordance with the selected path; and

said step of estimating the error rate of the

signal comprises

a counting step of counting the number of times

of normalization, performed when generating a state

20 metric, within a predetermined time and

an estimating step of estimating an error rate

of said signal by the number of times of normalization

counted by said counting step.

28. A decoding method as set forth in claim 27,

25 wherein, in the estimating step, the error rate is

estimated based on a table establishing correspondence between the number of times of normalization and the error rate on a channel.

29. A decoding method as set forth in claim 27, wherein, in the estimating step, the number of times of normalization counted in the counting step is inserted into a predetermined function.

30. A decoding method as set forth in claim 27, wherein, in the counting step, only the number of times of normalization for a signal of a predetermined transmission system or a predetermined coding rate is counted.

31. A receiver (6) for receiving and decoding a signal which has been convolutionally coded, punctured, and quadrature-modulated,

said receiver provided with:

a depuncturing means (8) for performing processing reverse to said puncturing and

a decoding means (9) for decoding the above punctured quadrature-modulated data;

said decoding means (9) having

a branch metric calculating means (31) for calculating a branch metric of the above punctured quadrature-modulated data,

an adding, comparing, and selecting means (11,

32) having an error estimating means (11) for estimating

an error rate of a signal and adding and comparing it for

the calculated branch metric and for selecting a path

with reference to the result of estimation by the error

5   estimating means, and

a path memory means (33) for outputting a

signal matrix in accordance with the path selected by

said adding, comparing, and selecting means; and

said error rate estimating means (11) is

10   provided with:

a judging means (62) for judging a transmission

system or coding rate of the signal;

a counting means (91) for counting the number

of times of normalization, performed when generating a

15   state metric, for each of the plurality of transmission

systems or coding rates;

an estimating means (92, 111) for estimating

the error rate for each signal by the number of times of

normalization counted by the counting means; and

20   a selecting means for selecting one of a

plurality of error rates for each signal estimated by the

estimating means.

32. A receiver as set forth in claim 31, wherein

said selecting means selects the error rate according to

25   the transmission system or the coding rate judged by the

judging means.

33. A receiver as set forth in claim 31, wherein the selecting means selects an error rate to be output by comparing a plurality of error rates input with a

5 predetermined reference value.

34. A decoding method for decoding a signal which has been convolutionally coded, punctured, and quadrature-modulated,

said decoding method provided with:

10 a depuncturing step for performing processing reverse to said puncturing and

a decoding step for decoding the above punctured quadrature-modulated data;

said decoding step comprising

15 a step of calculating a branch metric of the above punctured quadrature-modulated data,

a step of estimating an error rate of a signal and adding and comparing it for the calculated branch metric and for selecting a path with reference to the

20 estimated error rate, and

a step of outputting a signal matrix in accordance with the selected path; and

said error rate estimating step of estimating the error rate comprises

25 a judging step of judging a transmission system

or coding rate of the signal;

a counting step of counting the number of times
of normalization, performed when a state metric is
generated, for each of the plurality of transmission

5   systems or coding rates;

an estimating step of estimating the error rate
for each signal by the number of times of normalization
counted in the counting step; and

a selecting step of selecting one of a

10   plurality of error rates for each signal estimated in the
estimating step.

35.   A decoding method as set forth in claim 34,
wherein, in the selecting step, an error rate in
accordance with the transmission system or coding rate

15   judged by said judging step is selected.

36.   A decoding method as set forth in claim 34,
wherein, in the estimating step, the error rate output is
selected comparing a plurality of input error rates and a
predetermined reference value.

20   37.   A receiver (6) for receiving and decoding a
signal which has been convolutionally coded, punctured,
and modulated by a plurality of coding systems or coding
rates,

said receiver provided with:

25   a depuncturing means (8) for performing

processing reverse to said puncturing and

a decoding means (9) for decoding the above

punctured quadrature-modulated data;

said decoding means having

5   a branch metric calculating means (31) for

calculating a branch metric of the above punctured

quadrature-modulated data,

an adding, comparing, and selecting means (11,

32) having an error estimating means (11) for estimating

10   an error rate of a signal and adding and comparing it for

the calculated branch metric and for selecting a path

with reference to the result of estimation by the error

estimating means, and

a path memory means (33) for outputting a

15   signal matrix in accordance with the path selected by

said adding, comparing, and selecting means; and

said error rate estimating means is provided

with:

a counting means (91) for counting the number

20   of times of normalization, performed when generating a

state metric, within a predetermined time,

an estimating means (92, 111) for estimating

the error rate of the signal by the number of times of

normalization counted by the counting means, and

25   a multiplying means (111) for determining a

value for multiplication with the error rate for each

signal according to a value of the error rate estimated

by the estimating means for a predetermined transmission

system or coding rate among the transmission systems or

5   coding rates and multiplying with that value, and

an outputting means for adding and outputting

the error rate for each signal output from the

multiplying means.

38.   A decoding method for decoding a signal which

10   has been convolutionally coded, punctured, and modulated

by a plurality of modulation systems or coding rates,

said decoding method provided with:

a depuncturing step for performing processing

reverse to said puncturing and

15   a decoding step for decoding the above

punctured quadrature-modulated data;

said decoding step comprising

a step of calculating a branch metric of the

above punctured quadrature-modulated data,

20   a step of estimating an error rate of a signal

and adding and comparing it for the calculated branch

metric and for selecting a path with reference to the

estimated error rate, and

a step of outputting a signal matrix in

25   accordance with the selected path; and

said step of estimating the error rate of the

signal comprises

a counting step of counting the number of times

of normalization, performed when generating a state

5   metric, for each of a plurality of transmission systems

or coding rates,

an estimating step of estimating an error rate

for each signal by the number of times of normalization

counted by said counting step,

10   a multiplying step of determining a value for

multiplication with the error rate for each signal

according to a value of the error rate estimated by the

estimating step for a predetermined transmission system

or coding rate among the transmission systems or coding

15   rates and multiplying with that value, and

an outputting step of adding and outputting the

error rate for each signal output in the multiplying

step.

- 75 -

ABSTRACT

To reduce the size of the device for judging the error rate on a channel and reducing the amount of processing, a normalization accumulator cumulatively adds the number of times that normalization is performed within a predetermined time in an ACS circuit calculating a state metric. The table stores a table establishing correspondence between the number of times of normalization cumulatively added by the normalization accumulator. The table uses the stored table to judge and output an error rate corresponding to the input cumulative number of times of normalization.

FIG.1
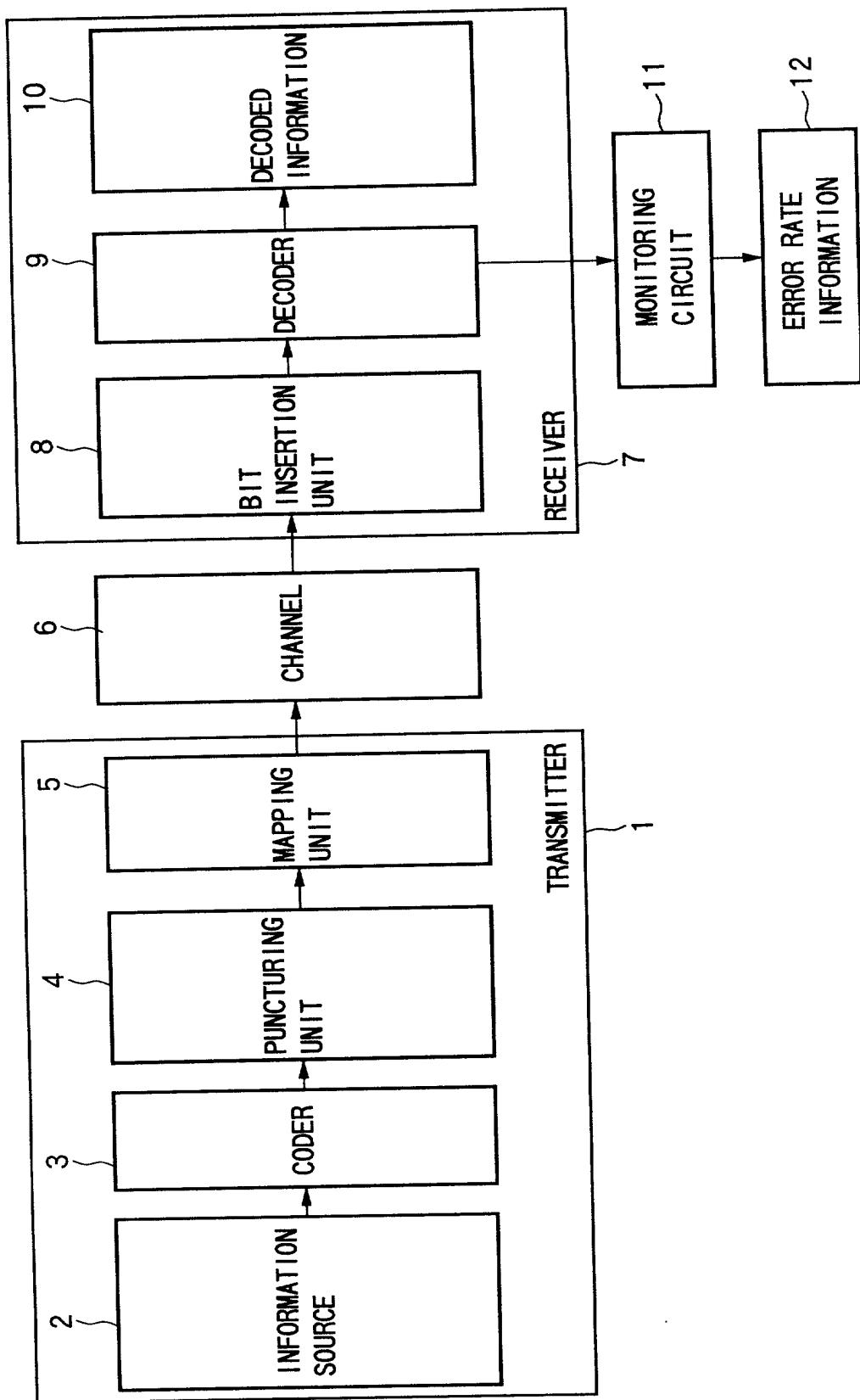
FIG.2
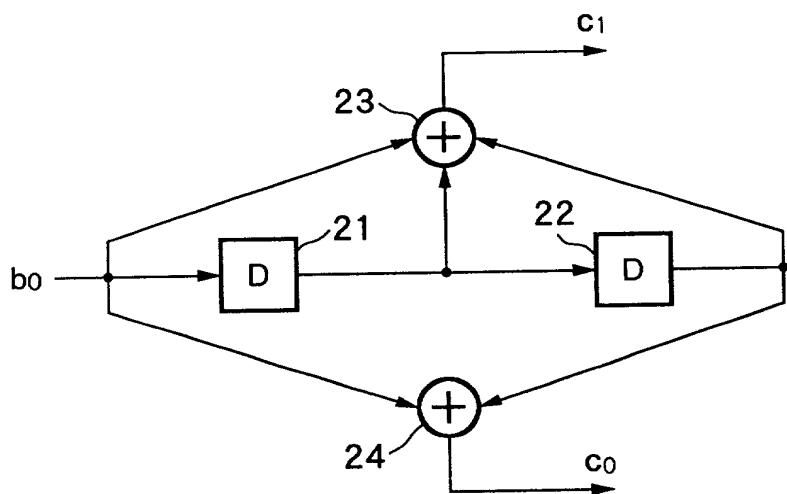
CODER 3

FIG.3A
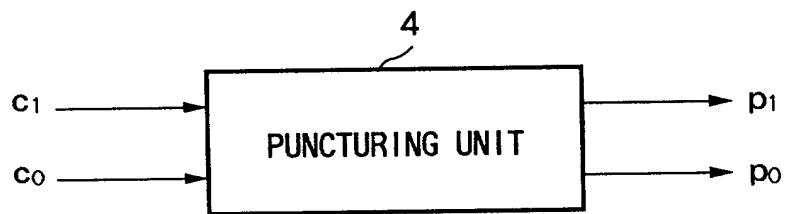
FIG.3B

c_1	1	1	0
c_0	1	0	1

FIG.4A INPUT

c_1	X_1	X_2	X_3	X_4	X_5	X_6
c_0	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6

FIG.4B OUTPUT

p_1	X_1	Y_3	X_4	Y_6
p_0	Y_1	X_2	Y_4	X_5

FIG.5

FIG.6A

p'_1 → BIT INSERTION UNIT → c'_1
p'_0 → → c'_0

8
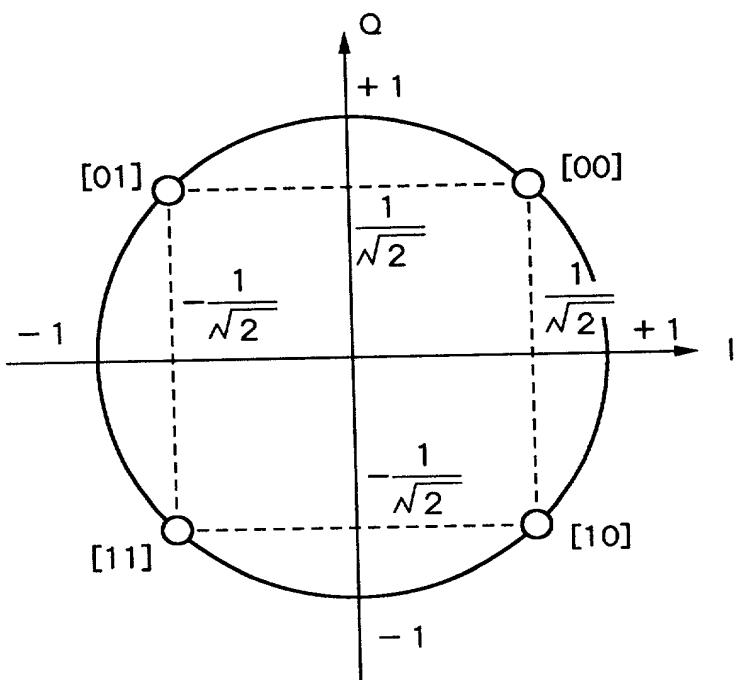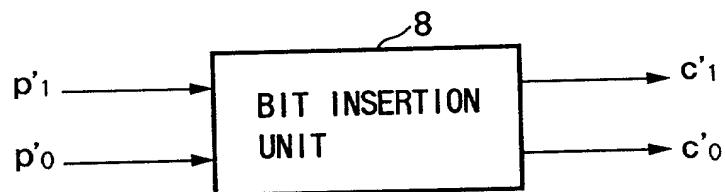
FIG.6B

DEPUNCTURING TABLE

p'_1	1	1	0
p'_0	1	0	1

FIG.7A INPUT

p'_1	X_1	Y_3	X_4	Y_6
p'_0	Y_1	X_2	Y_4	X_5

FIG.7B OUTPUT

c'_1	X_1	X_2	0	X_4	X_5	0
c'_0	Y_1	0	Y_3	Y_4	0	Y_6

4/30

FIG.8

FIG.9

FIG.10

STATE 00 ——→ 45-1

BM00 ——→ ⊕

STATE 01 ——→

BM11 ——→ ⊕ 46-1

00 ┄─41

SELECTOR 47-1

48-1

——→ STATE 00

STATE 10 ——→ 45-2

BM10 ——→ ⊕

STATE 11 ——→

BM01 ——→ ⊕ 46-2

01 ┄─42

SELECTOR 47-2

48-2

——→ STATE 01

STATE 00 ——→ 45-3

BM11 ——→ ⊕

STATE 01 ——→

BM00 ——→ ⊕ 46-3

10 ┄─43

SELECTOR 47-3

48-3

——→ STATE 10

STATE 10 ——→ 45-4

BM01 ——→ ⊕

STATE 11 ——→

BM10 ——→ ⊕ 46-4

11 ┄─44

SELECTOR 47-4

48-4

——→ STATE 11

ACS CIRCUIT 32
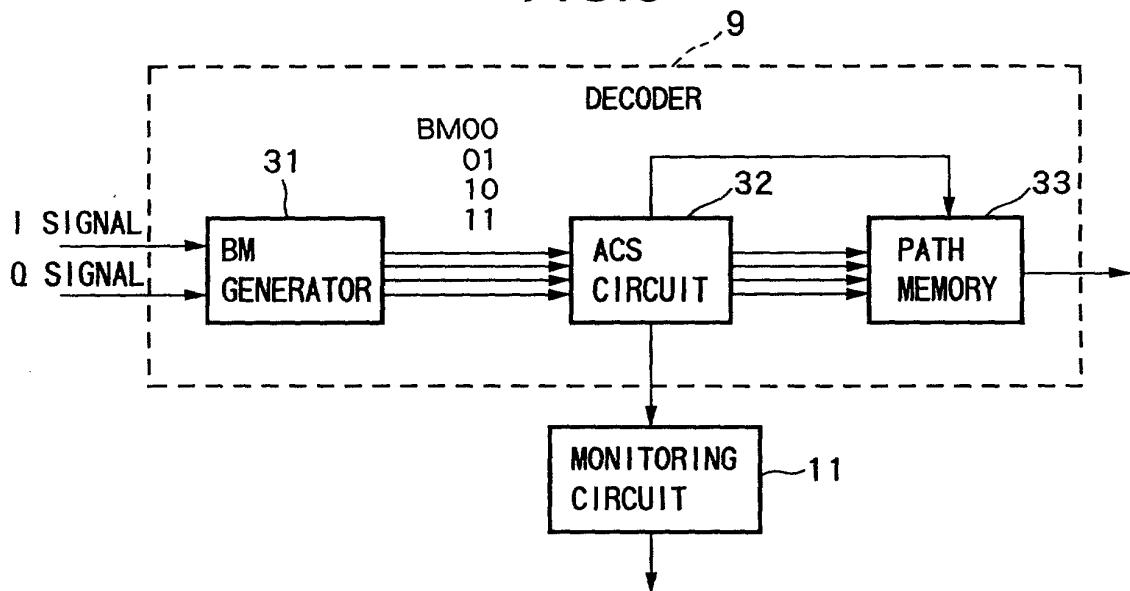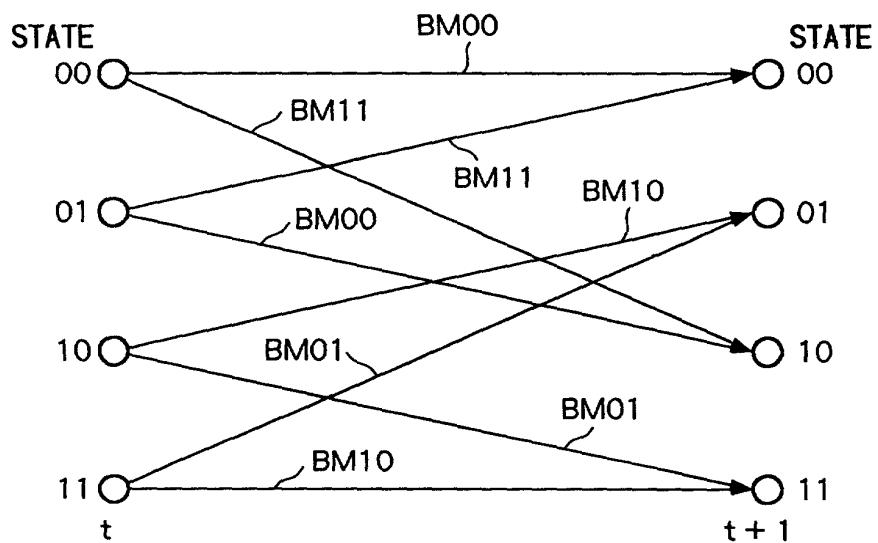
6/30
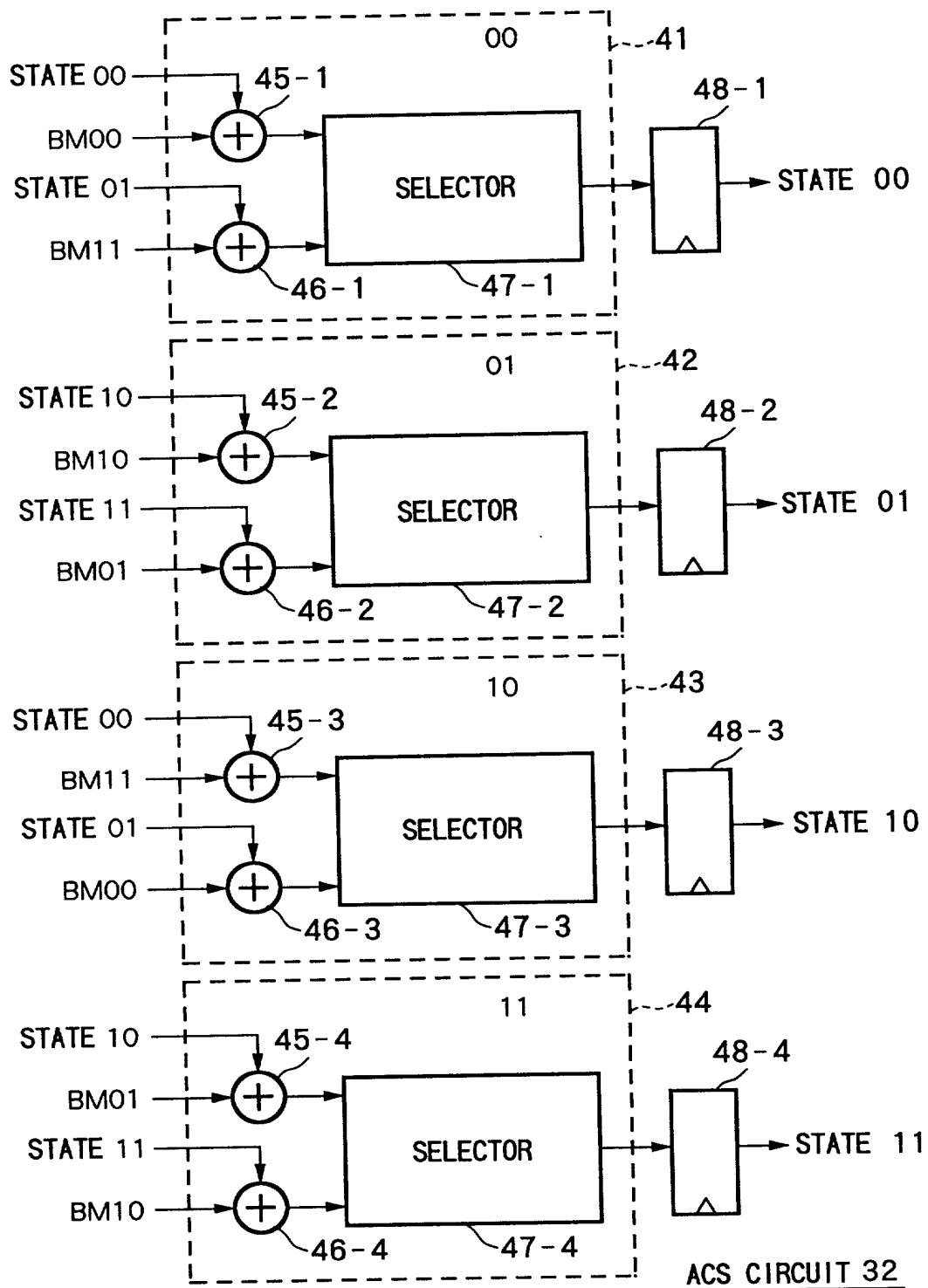
FIG.11
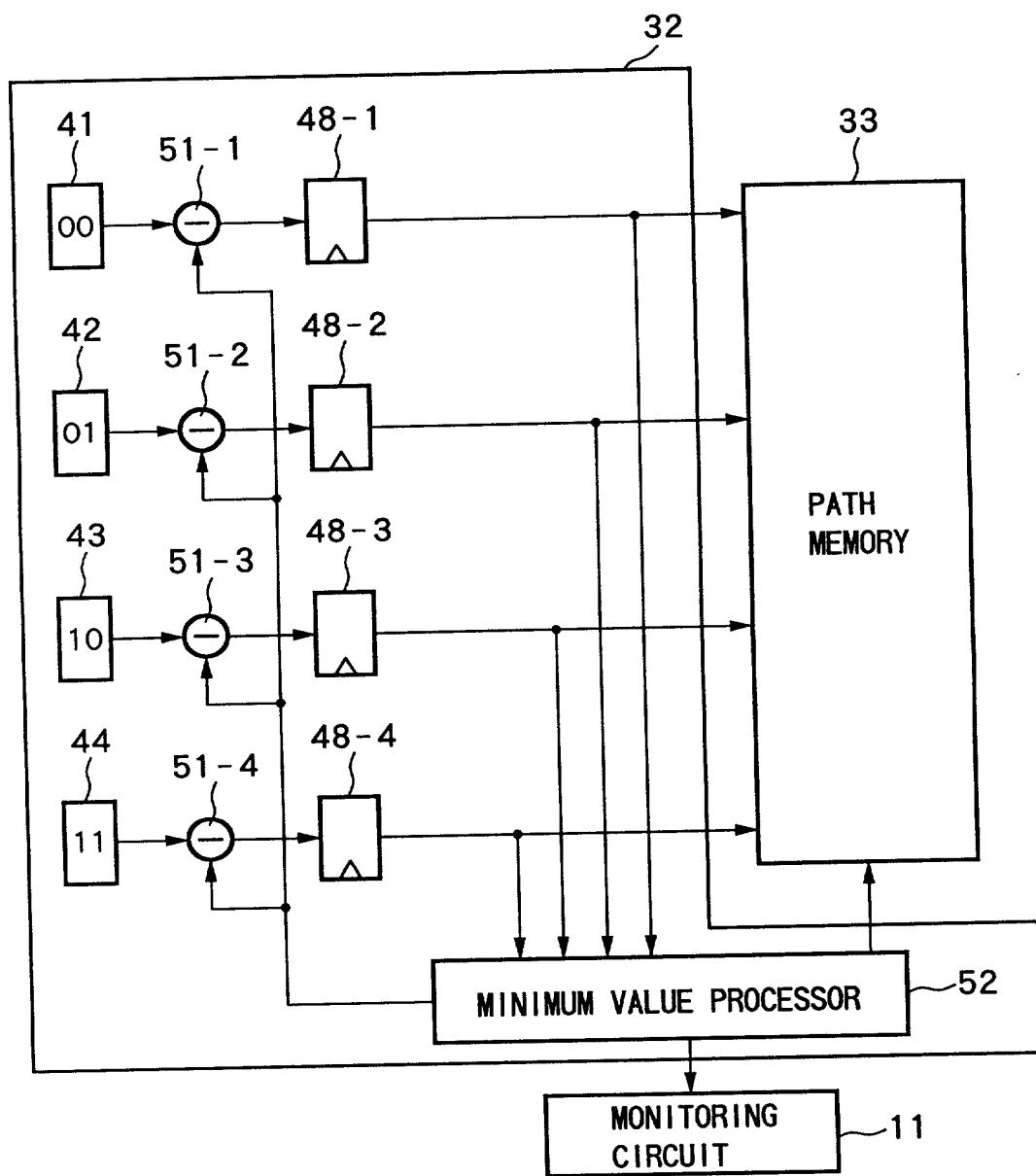
FIG.12
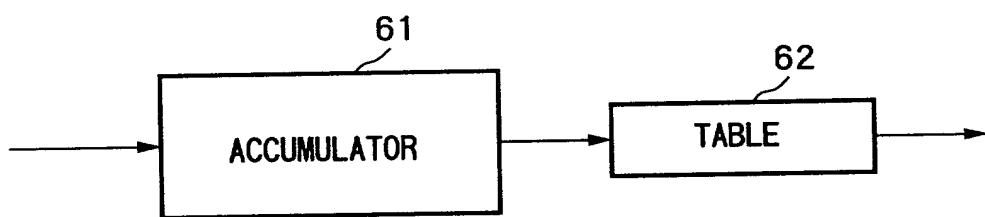
MONITORING CIRCUIT 11

FIG.13
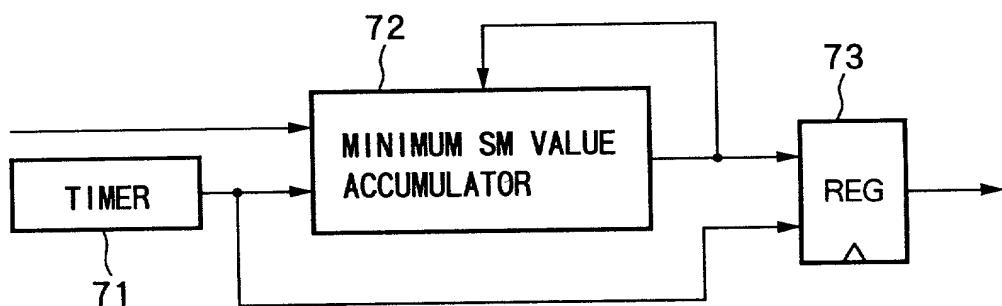
ACCUMULATOR 61
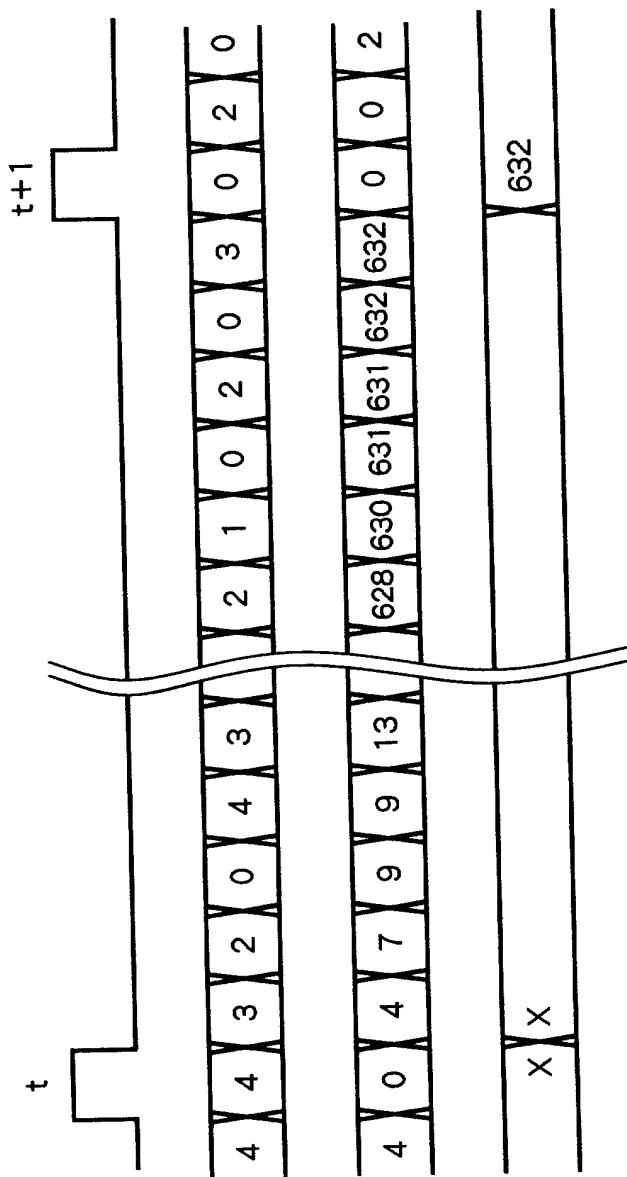
FIG.14A TIMER OUTPUT

t									t+1			

FIG.14B MINIMUM SM VALUE

| 4 | 4 | 3 | 2 | 0 | 3 | | 2 | 1 | 0 | 2 | 0 | 3 | 0 | 2 | 0 |

FIG.14C MINIMUM SM VALUE ACCUMULATOR

| 4 | 0 | 4 | 7 | 9 | 13 | | 628 | 630 | 631 | 631 | 632 | 632 | 0 | 0 | 2 |

FIG.14D OUTPUT TIMING

| X | X X | | 632 | 632 |

FIG.15A

QPSK R = 1/2	
ROM	
COUNTER VALUE	C/N
EQUAL OR MORE 22720	3.00
EQUAL OR MORE 22080 LESS THAN 22720	2.50
EQUAL OR MORE 21440 LESS THAN 22080	2.00
LESS THAN 21440	1.50

FIG.15B

| QPSK R = 3/4	
ROM	
COUNTER VALUE	C/N
EQUAL OR MORE 36160	2.20
EQUAL OR MORE 35520 LESS THAN 36160	1.50
EQUAL OR MORE 34880 LESS THAN 35520	1.00
LESS THAN 34880	0.85

FIG.16

11/30
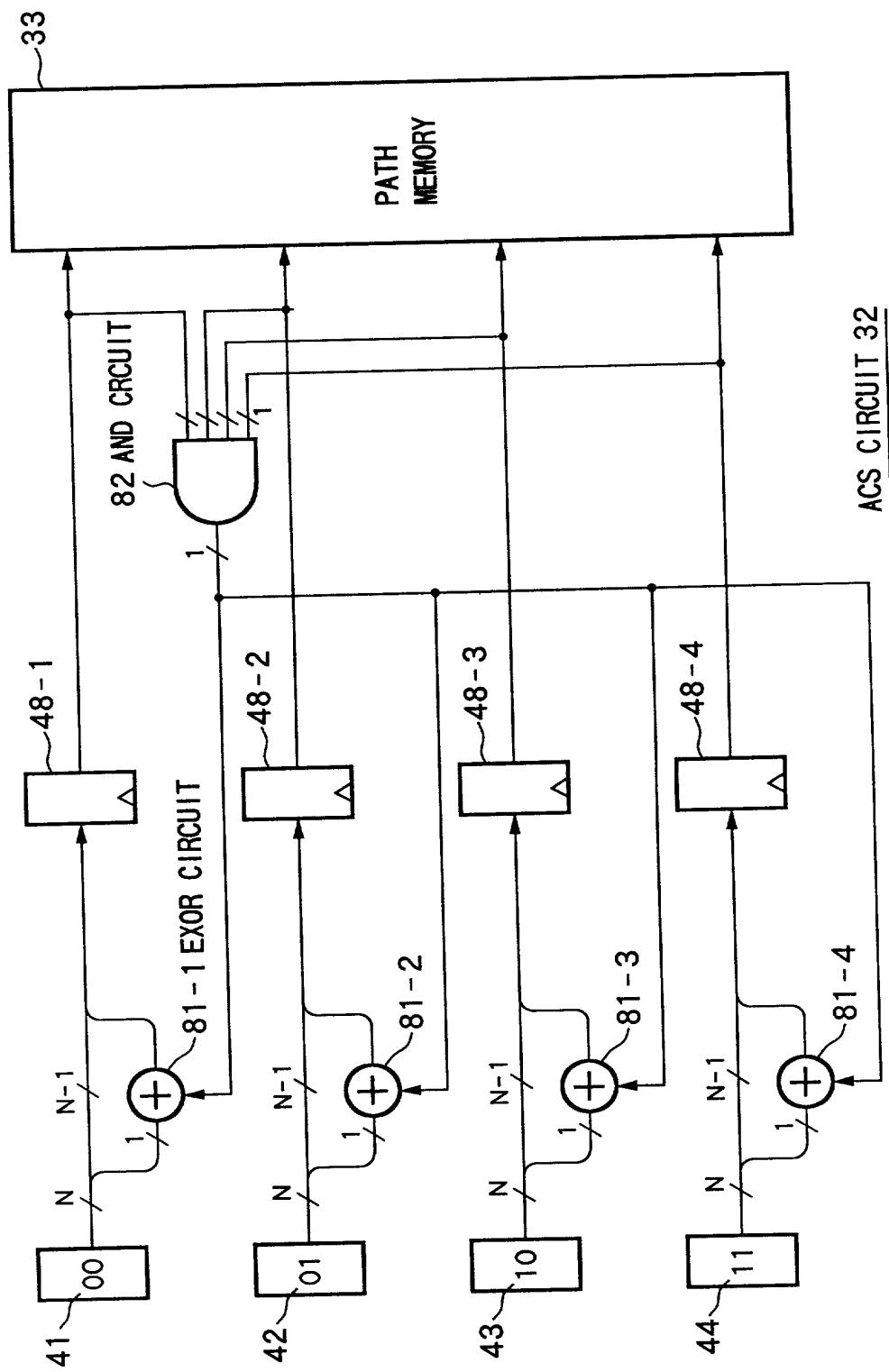
FIG.17
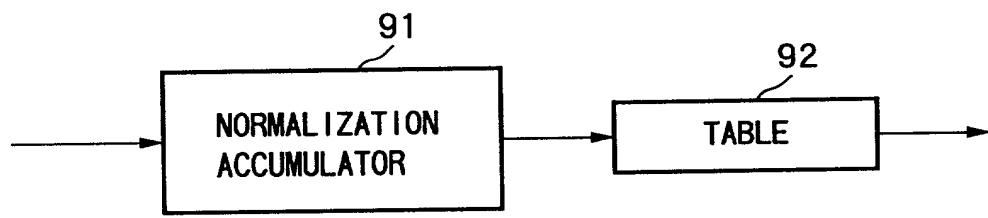
MONITORING CIRCUIT 11

FIG.18

NORMALIZATION ACCUMULATOR 91

FIG.19A   TIMER
          OUTPUT

FIG.19B   NORMALIZATION
          INFORMATION

FIG.19C   COUNTER

FIG.19D   OUTPUT

TIME UNIT
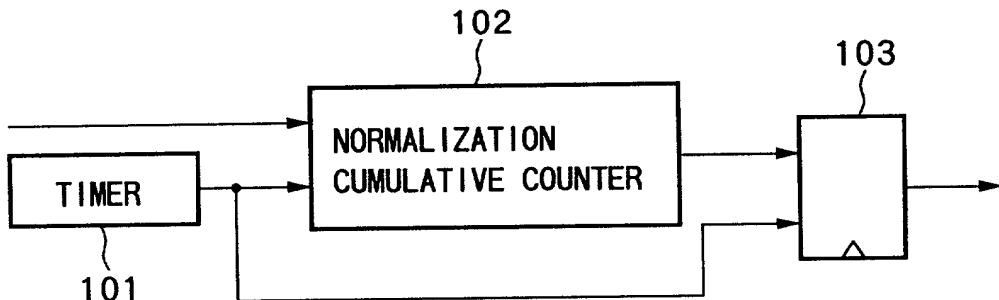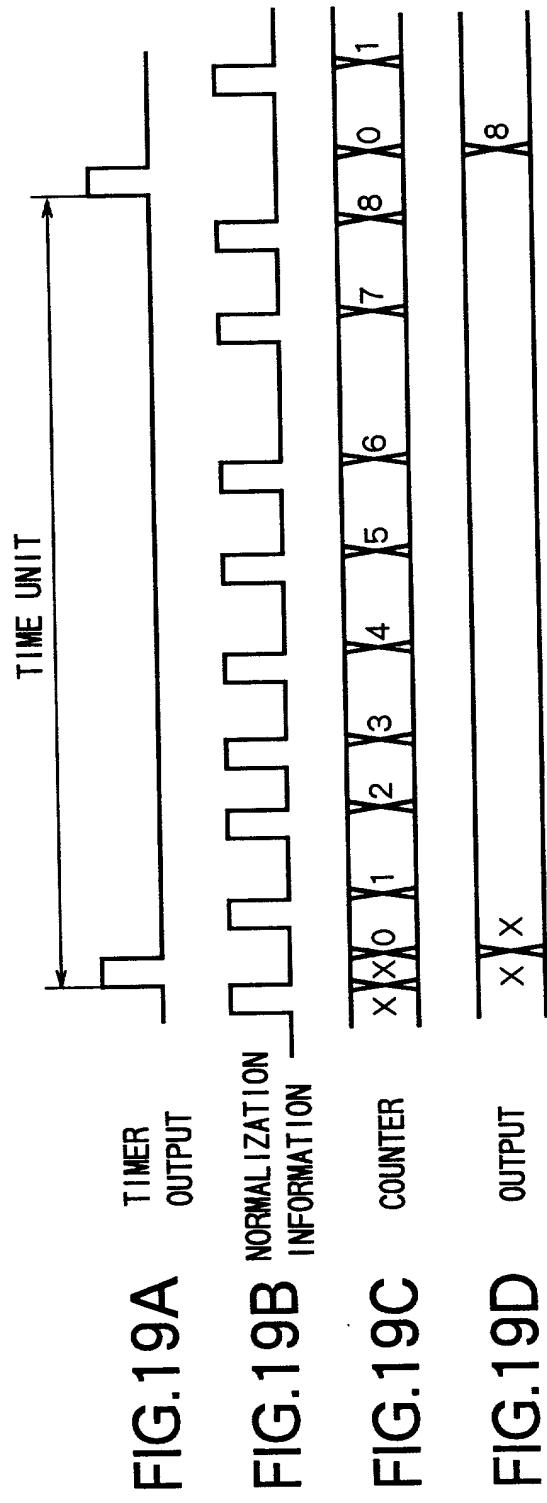
FIG.20A

QPSK R = 1/2	
COUNTER VALUE	BER
355 OR MORE	0.50×10^{-3}
345 TO 354	1.90×10^{-3}
335 TO 344	0.80×10^{-2}
334 OR LESS	0.20×10^{-1}

FIG.20B

QPSK R = 3/4	
COUNTER VALUE	BER
565 OR MORE	4.80×10^{-3}
555 TO 564	3.20×10^{-2}
545 TO 554	1.00×10^{-1}
544 OR LESS	1.90×10^{-1}

FIG.21A

QPSK R = 1/2	
COUNTER VALUE	C/N
355 OR MORE	3.00
345 TO 354	2.50
335 TO 344	2.00
334 OR LESS	1.50

FIG.21B

QPSK R = 3/4	
COUNTER VALUE	C/N
565 OR MORE	2.20
555 TO 564	1.50
545 TO 554	1.00
544 OR LESS	0.85

FIG.22
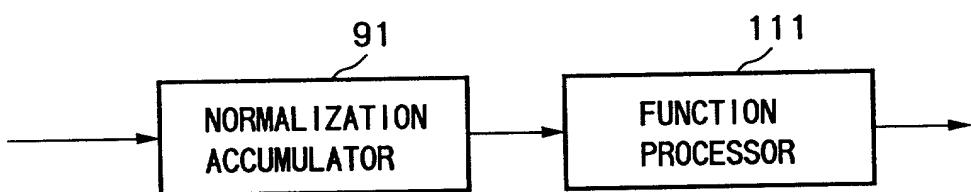
91

NORMALIZATION ACCUMULATOR

111

FUNCTION PROCESSOR

<u>MONITORING CIRCUIT 11</u>

FIG.23

VALUE OF TABLE

NORMALIZED
CUMULATIVE
NUMBER COUNTED
PER PREDETERMINED
TIME

f

FIG.24

QPSK R＝3／4	QPSK R＝1／2	QPSK R＝3／4	QPSK R＝1／2

FIG.25

FIG.26

NORMALIZATION
INFORMATION

CODING RATE
INFORMATION

91

NORMALIZATION
ACCUMULATOR

92

TABLE

MONITORING CIRCUIT 11

FIG.27

NORMALIZATION
INFORMATION

CODING RATE
INFORMATION

TIMER

101

102

NORMALIZATION
CUMULATIVE
COUNTER

103

NORMALIZATION ACCUMULATOR 91
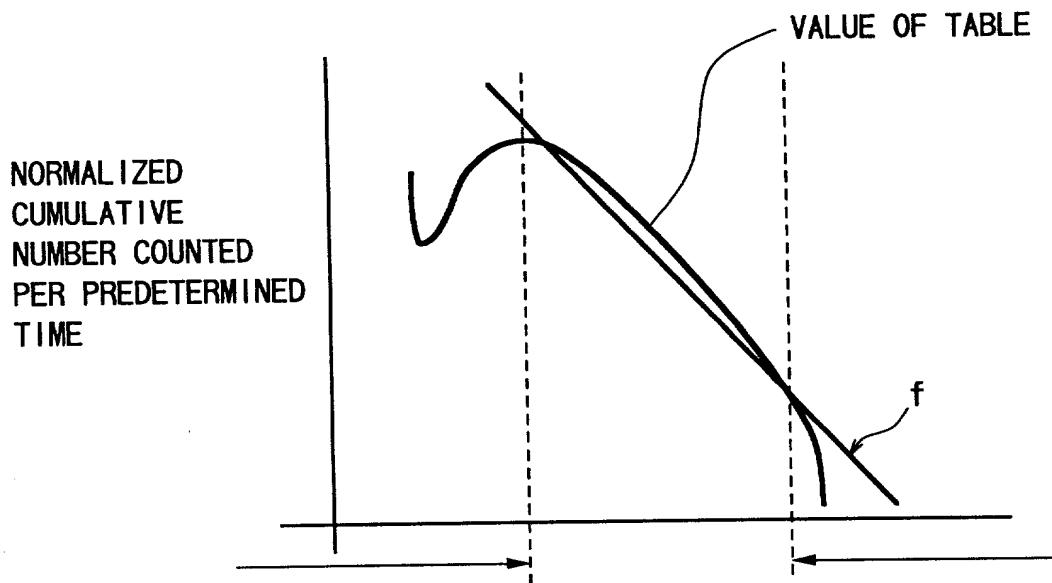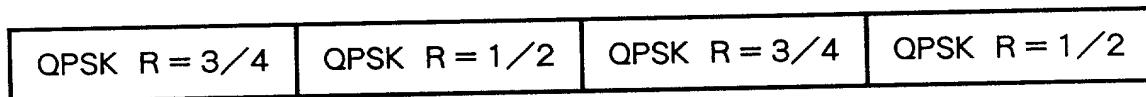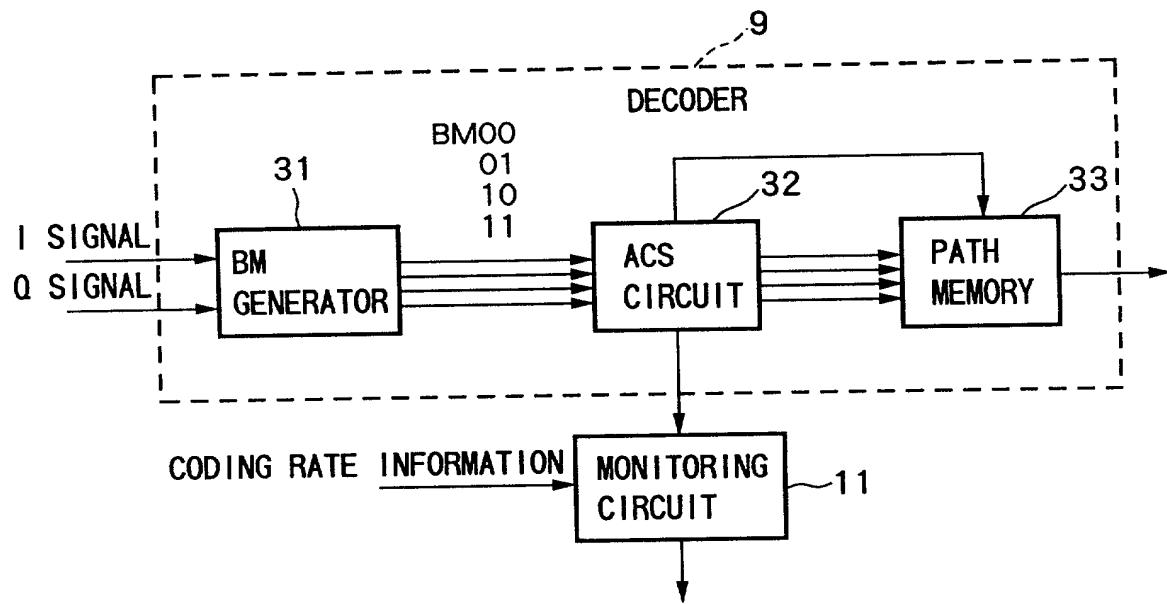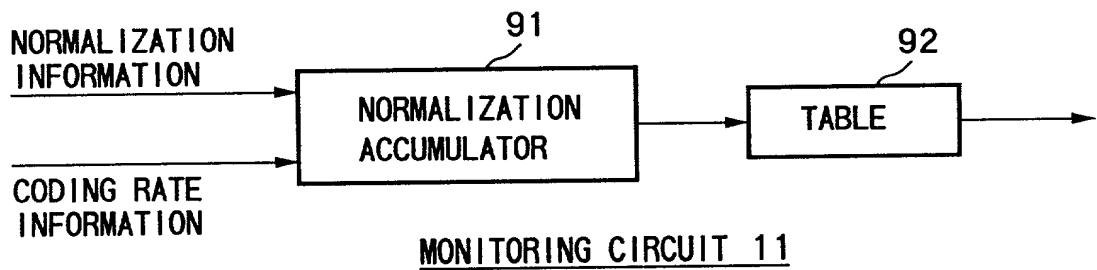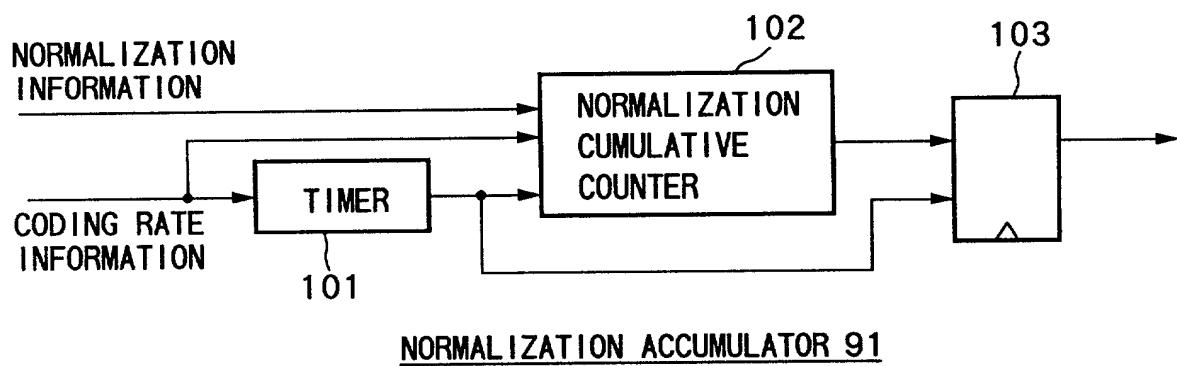
FIG.28A CODING OR MODULATING METHOD

| QPSK R = 1/2 | QPSK R=3/4 | QPSK R = 1/2 |

FIG.28B TIMER OUTPUT

FIG.28C CODING RATE INFORMATION
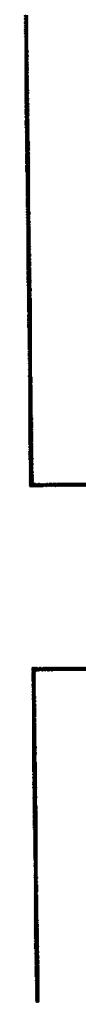
FIG.28D NORMALIZATION INFORMATION

FIG.28E COUNTER

| x | x | 0 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 0 | 1 |

FIG.28F OUTPUT

| x | x | 6 |
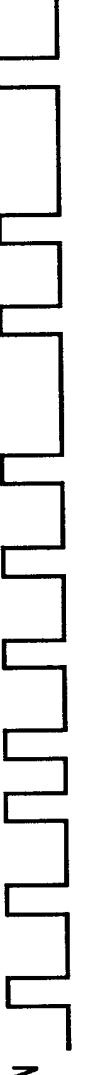
FIG.29
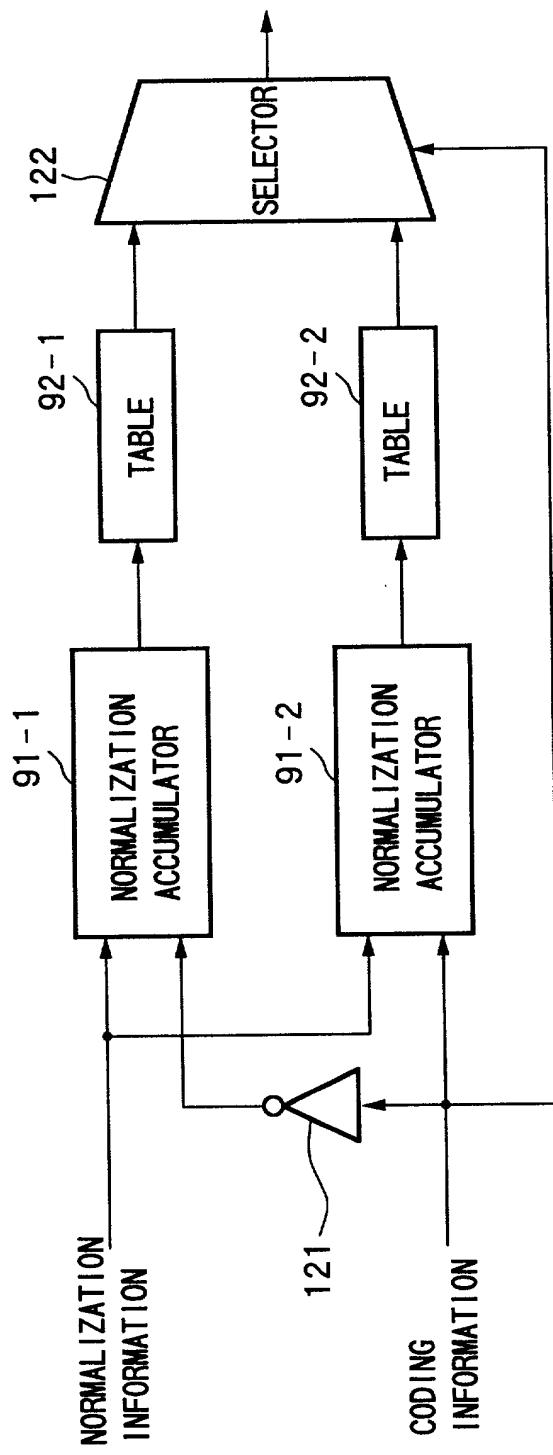
MONITORING CIRCUIT 11

FIG.30

MONITORING CIRCUIT 11

FIG.31

INPUT 0 ——————

```
IF (INPUT 0>C)
THEN
    OUTPUT=INPUT 0
ELSE
    OUTPUT=INPUT 1
```

——→ OUTPUT

INPUT 1 ——————

FIG.32

141-1

142

141-2

SELECTOR 131
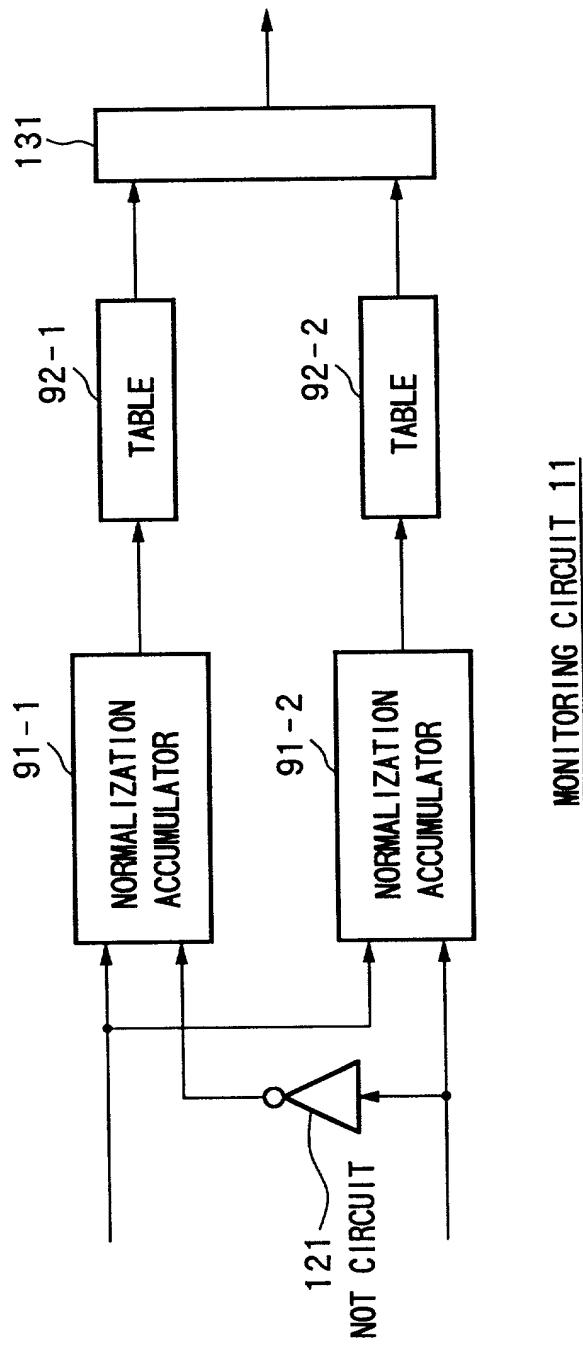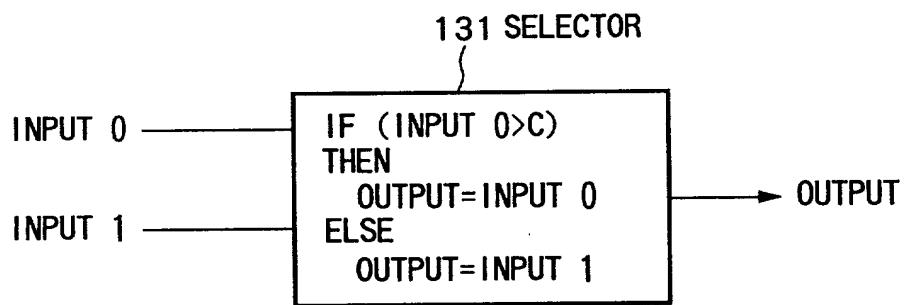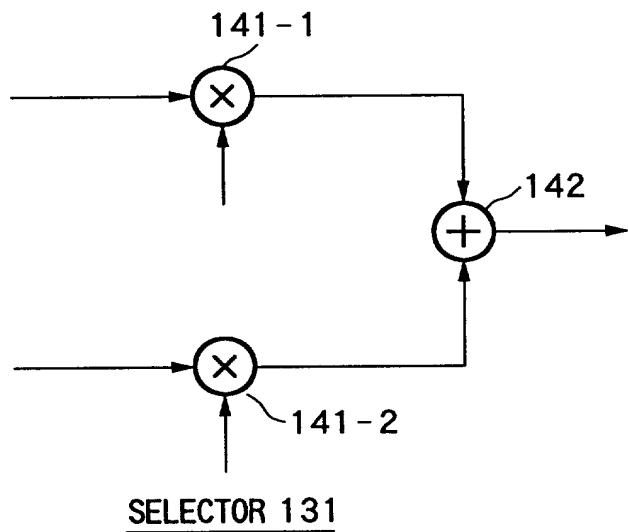
FIG.33

ESTIMATED VALUE OF C/N IN QPSK TRANSMISSION AT R=1/2	WEIGHTING(QPSK R=1/2)	WEIGHTING(QPSK R=3/4)
FROM 2.0[dB] TO 3.0[dB]	1.0	0.0
FROM 1.5[dB] TO 2.0[dB]	0.5	0.5
1.5[dB] OR LESS	0.0	1.0

TABLE

FIG.34

CODING RATE OF QPSK R=3/4	WEIGHTING (QPSK R=1/2)	WEIGHTING (QPSK R=3/4)
EQUAL OR MORE 565	0.0	1.0
EQUAL OR MORE 565 LESS THAN 565	0.5	0.5
LESS THAN 555	1.0	0.0

TABLE

FIG.35

FIG.36


```
        91-1                      92-1            131
  ┌──────────────┐          ┌──────────┐    ┌──────────┐
─▶│ NORMALIZATION│─────────▶│  TABLE   │───▶│          │
  │ ACCUMULATOR  │          └──────────┘    │          │
  └──────────────┘                          │          │
                                            │ SELECTOR │──▶
        91-2                      92-2       │          │
  ┌──────────────┐          ┌──────────┐    │          │
─▶│ NORMALIZATION│─────────▶│  TABLE   │───▶│          │
  │ ACCUMULATOR  │          └──────────┘    └──────────┘
  └──────────────┘
```

MONITORING CIRCUIT 11
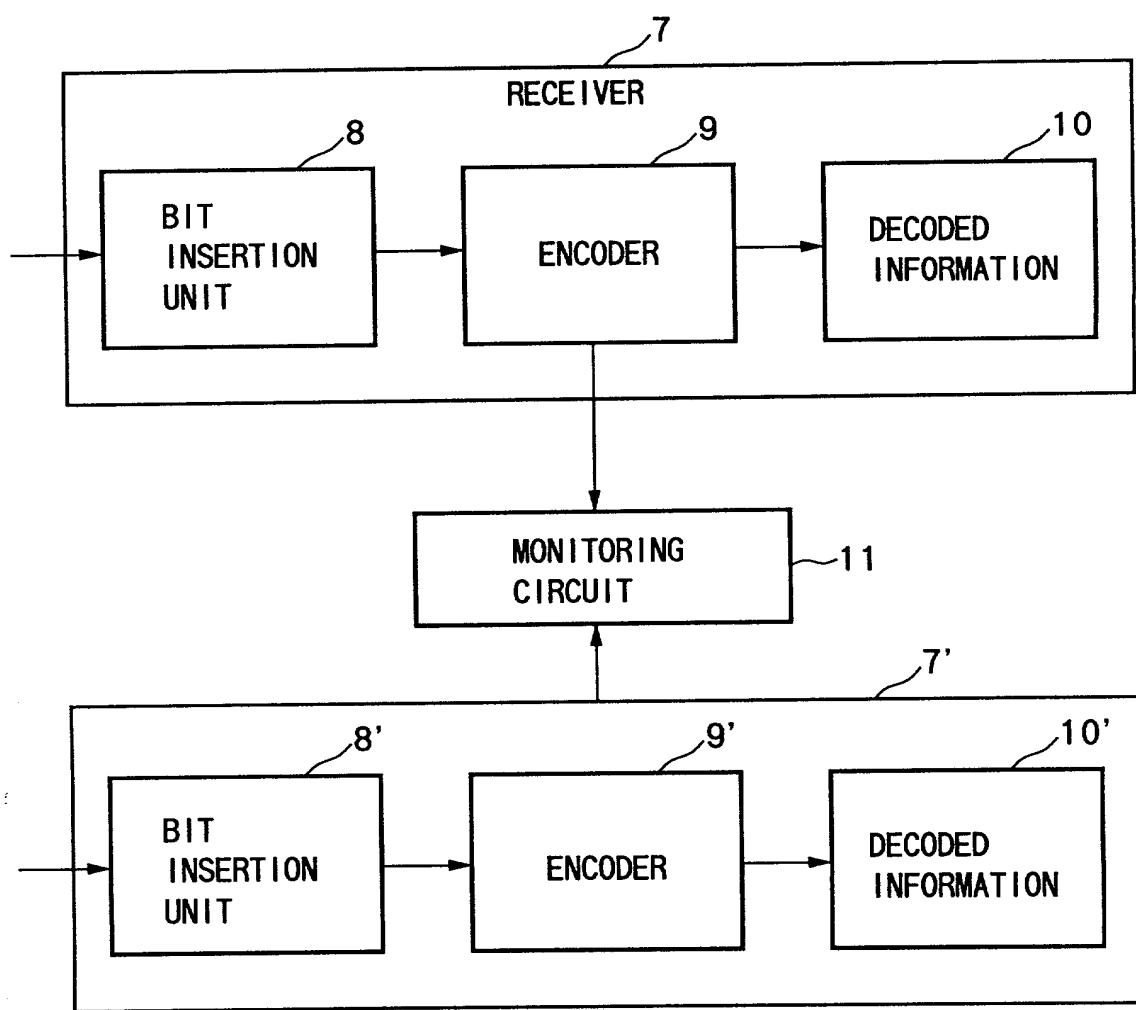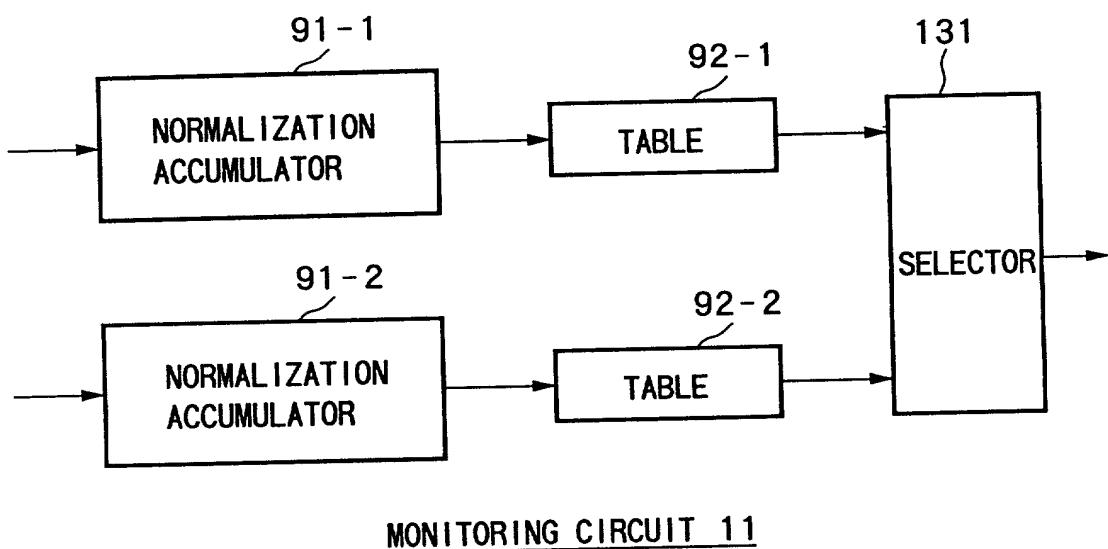
FIG.37

ESTIMATED VALUE OF C/N IN QPSK TRANSMISSION AT R=3/4	WEIGHTING(QPSK R=1/2)	WEIGHTING(QPSK R=3/4)
2.20[dB] OR MORE	1.0	0.0
FROM 1.5[dB] TO 2.20[dB]	0.5	0.5
FROM 0.8[dB] TO 1.5[dB]	0.0	1.0

TABLE

FIG.38

1

1001	1002	1003	1004	1005
CPU	ROM	RAM	EXTERNAL STORAGE	COMMUNICATIONS I/F

1006

# FIG.39

7
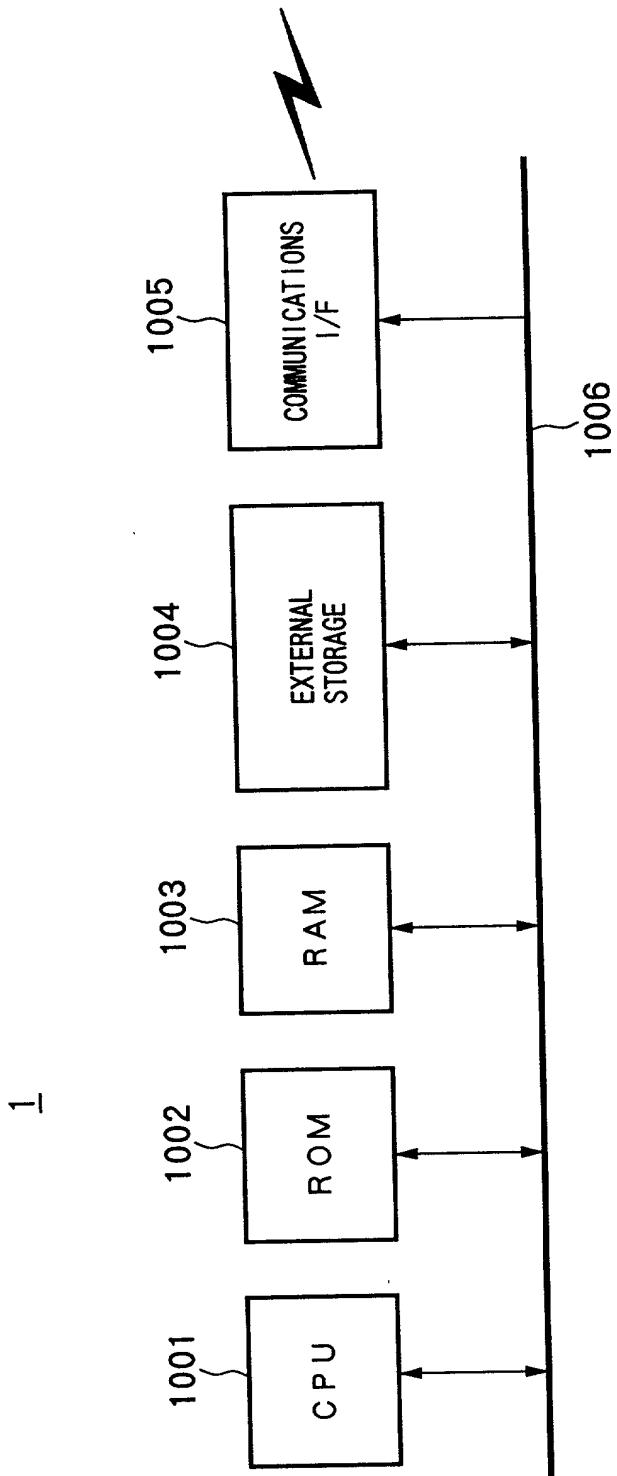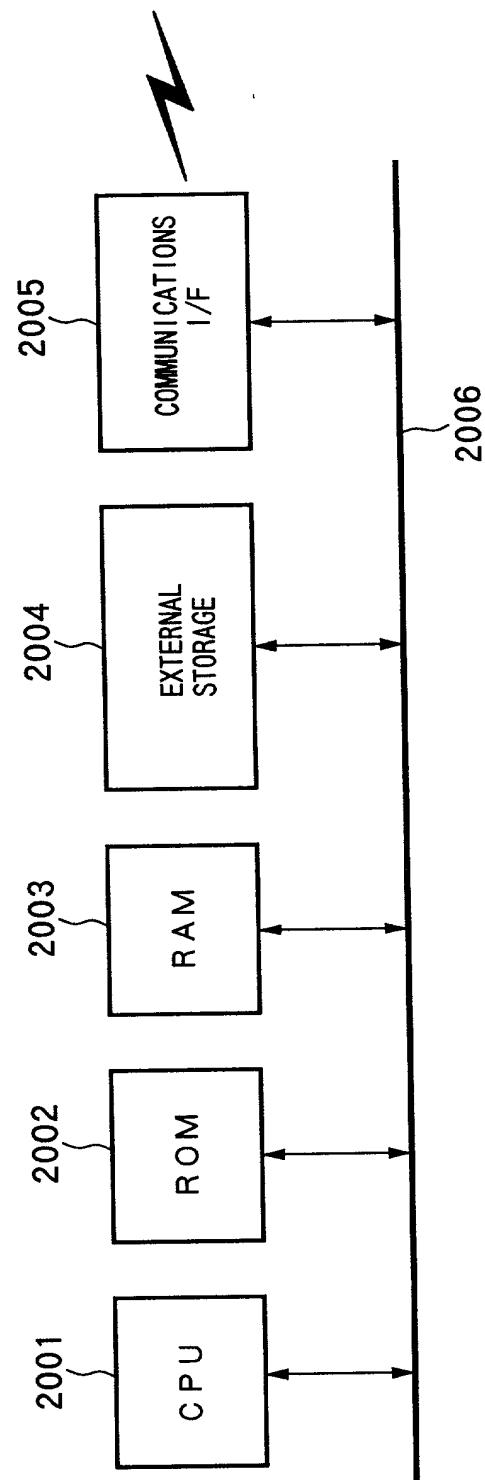
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こと）

②

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact al business in the Patent and Trademark Office connected therewith (list name and registration number)

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（第三以下の共同発明者についても同様に記載し、著名をすること）

(Supply similar information and signature for third and subsequent joint inventors)

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Declaration and Power of Attorney for Patent Application

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Japanese Language Declaration

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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name:

I believe I am the original, first and sole inventor if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

ERROR RATE ESTIMATING DEVICE, RECEIVER USING ERROR RATE ESTIMATING DEVICE, ERROR RATE ESTIMATING METHOD, RECEIVING METHOD USING ERROR RATE ESTIMATING METHOD, AND INFORMATION RECORDING MEDIUM

the specification of which is attached hereto unless the following box is checked:

☒ was filed on January 5, 2000
as United States Application Number of
PCT International Application Number   PCT/JP00/00013
＿＿＿＿ and was amended on
＿＿＿＿ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

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which designated at least one country other than the United States listed
below and have also identified below, by checking the box, any foreign
application for patent or inventor's certificate or PCT international
application having a filing date before that of the application for which
priority is claimed.

Prior Foreign Application(s)

外国での先行出願

Priority Not Claimed

優先権主張なし

✓ 11-001790   Japan
(Number)   (Country)
（番号）   （国名）

<u>7 January 1999</u>
(Day/Month/Year Filed)   ☐

PCT/JP00/00013   PCT
(Number)   (Country)
（番号）   （国名）

<u>5 January 2000</u>
(Day/Month/Year Filed)   ☐

_____
(Number)   (Country)
（番号）   （国名）

_____
(Day/Month/Year Filed)   ☐

_____
(Number)   (Country)
（番号）   （国名）

_____
(Day/Month/Year Filed)   ☐

_____
(Number)   (Country)
（番号）   （国名）

_____
(Day/Month/Year Filed)   ☐

_____
(Number)   (Country)
（番号）   （国名）

_____
(Day/Month/Year Filed)   ☐

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_____
(Application No.)   (Filing Date)
（出願番号）   （出願日）

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(Application No.)   (Filing Date)
（出願番号）   （出願日）

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(Application No.)   (Filing Date)
（出願番号）   （出願日）

(Status: Patented, Pending, Abandoned)
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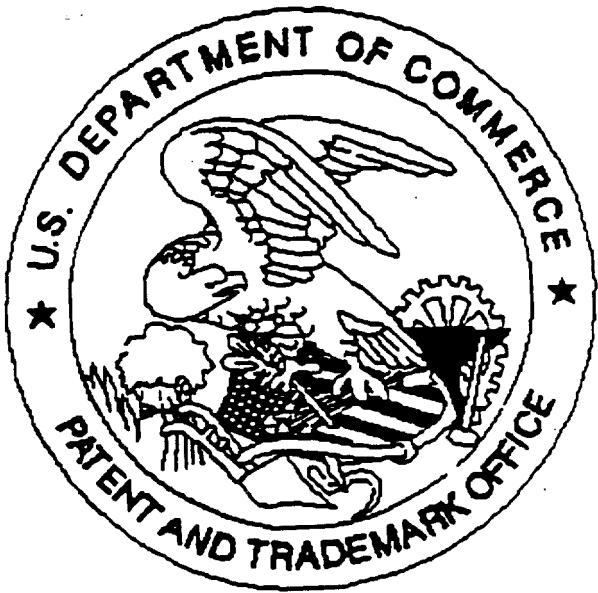
Application deficiencies found during scanning:

☐ Page(s) _36 of 30_ of _Drawings_ _____ were not present
for scanning.
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